TF 2011

TF 2011

F.M.

Signal Generator

INSTRUCTION MANUAL

MP MASTER
MA23628

MARCONI INSTRUMENTS

Instruction Manual
No. EB 2011
for

F.M. Signal Generator

TF 2011

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MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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Chapter 1

General information

1.1 FEATURES

This f. m. signal generator is primarily designed for measurements on receivers in the 130 to 180 MHz mobile radio band. Its deviation ranges of 3, 10 and 30 kHz cater for narrow band f.m. requirements, while its incremental frequency ranges of 10, 30 and 100 kHz give ample discrimination for reliable channel shifting.

A major feature is the very low level of sideband noise close to the carrier; this allows you to measure adjacent channel rejection of more than 80 dB on receivers with 12.5 kHz channel spacing.

Other characteristics such as stability, leakage and microphony all conform to the highest standards of receiver testing requirements. The signal generator also provides for external modulation and external fine tuning. A counter output provides a suitable r.f. level for monitoring the output frequency from the signal generator on a counter.

The continuously variable piston attenuator provides 0.03 μV to 200 mV e.m.f. in one scale.

The main tuning control has two speed operation: a main drive covering the range in 28 turns and a 9:1 reduction drive, allowing simple and accurate operation throughout the frequency band.

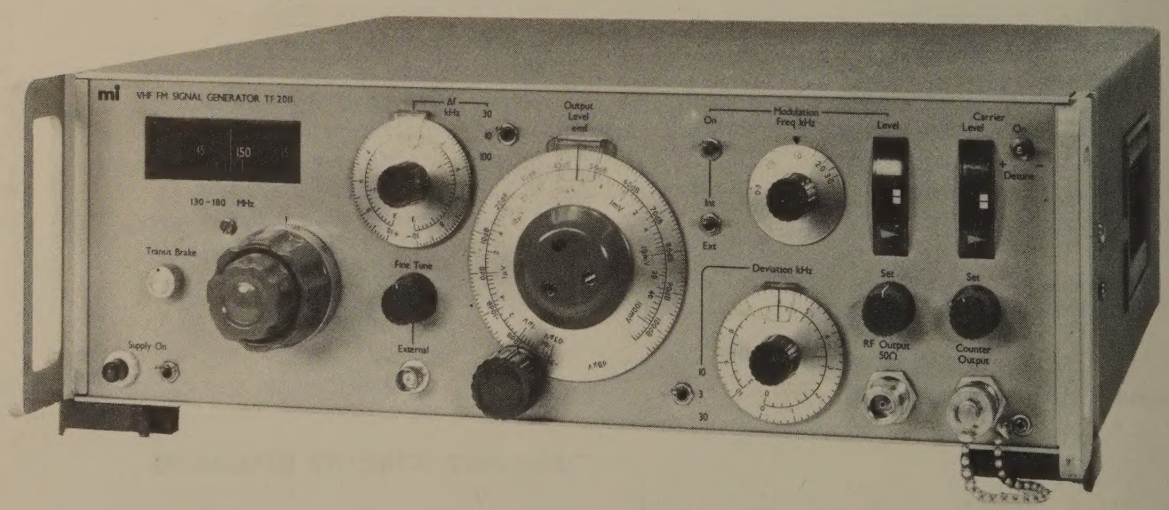


Fig. 1.1 F.M. Signal Generator TF 2011

1.2 DATA SUMMARY

FREQUENCY

Range :	130 to 180 MHz in one band.
Mechanical tuning :	2-speed: 9 and 28 turns.
Calibration accuracy :	Within ±1.0%.
Stability :	At a constant ambient temperature in the range 10 °C to 35 °C 15 minutes after switching on, the drift is typically 50 p.p.m. in the following 15 minute period. At a constant ambient temperature in the range 10 °C to 35 °C after one hour, the drift does not exceed 20 p.p.m. per 15 minutes; after two hours it does not exceed 10 p.p.m. per 15 minutes. After a 2 hour warm up period, for supply voltage changes of ±10% about 230 V or 115 V the frequency change is less than 4 p.p.m.
Attenuator reaction :	With the output terminated with 50 Ω, the change of frequency with respect to the frequency at 85 dBμV in the output range corresponding to attenuator settings between 104 dBμV and -30 dBμV is less than 2 kHz. At attenuator settings below 85 dBμV the frequency change is negligible.

ELECTRICAL FINE TUNING

Δ F :	Three calibrated ranges: ±10, 30 and 100 kHz. Accuracy: ±10% f.s.d.
Fine tune :	Uncalibrated control for precise adjustment; covers approximately 20 kHz.
Carrier detune switch :	Changes frequency by more than ±100 kHz.
External fine tuning :	A voltage change from 0 to -1 V gives a frequency change of approximately 40 kHz at 130 MHz and 20 kHz at 180 MHz.

R.F. OUTPUT

Level :	200 mV e.m.f. down to 0.03 μV.
Attenuator :	Piston calibrated -30 dB to +106 dB relative to 1 μV.
Total level accuracy (above 2 μV e.m.f.) :	Within ±1 dB.
Output impedance :	50 Ω with v.s.w.r. better than 1.2:1.
Counter output :	100 mV across a 50 Ω load.
C.W. distortion (individual harmonics) :	Less than 1%.

Leakage : With a two-turn loop of 1 inch diameter connected to a receiver, a signal cannot be detected at a distance greater than 1 inch from the generator with the receiver sensitivity set to 1 μV (with counter output socket cap in place).

FREQUENCY MODULATION

Deviation reference : A full-wave peak reading meter scaled with a reference point.

Deviation ranges : Three ranges are provided by means of a calibrated dial giving full scales of 3, 10 and 30 kHz peak deviation.

INTERNAL F.M.

Frequency range : 300 Hz - 3 kHz.

Deviation accuracy : ±6% f.s.d.

F.M. distortion : Less than 0.75% up to 10 kHz deviation.
Less than 1.5% up to 30 kHz deviation.

Modulation drive output : A socket monitors the Δ F (d.c.) and deviation (a.c.) drives to the r.f. unit.

EXTERNAL F.M.

Frequency range : 30 Hz - 15 kHz.

Deviation accuracy : ±6% f.s.d. at 1 kHz modulation frequency.

Frequency characteristic : For a constant audio frequency input to the external modulation socket, the deviation will remain within ±1.0 dB of that at 1 kHz.

Input level : 1.5 V r.m.s. into 600 Ω for maximum frequency deviation.

SPURIOUS SIGNAL COMPONENTS

A.M. on f.m. : At maximum deviation, less than 0.5%.

F.M. noise : With psophometric weighting as follows -

telephone - less than 3 Hz equivalent deviation,
broadcast - less than 10 Hz equivalent deviation.

Microphony : When checked on a mechanical vibrator, less than 3 kHz deviation is caused by $\frac{1}{2}$g acceleration in the range of 10 - 50 Hz and less than 12 kHz deviation in the range 10 - 80 Hz. At 10 Hz, $\frac{1}{2}$g corresponds to a displacement of 0.1 inch.

Sideband noise : Less than -140 dB/Hz relative to the carrier, 20 kHz from the carrier.

INTERNAL MODULATION OSCILLATOR

Range :	300 Hz - 3 kHz.
Dial accuracy :	±10%.
Output level :	0.7 V nominal e.m.f. at terminal.
Source impedance :	10 kΩ.
Distortion :	Less than 0.25%.

POWER REQUIREMENTS

(a.c. supply absolute limits) :	95 to 130 V or 190 to 264 V, 45 to 500 Hz, 12 VA.

DIMENSIONS AND WEIGHT :

Height	Width	Depth	Weight
152 mm (6 in)	430 mm (17 in)	455 mm (18 in)	13.6 kg (30 lb)

1.3 ACCESSORIES

Output lead, TM 4726/12, 50 Ω type N male - type N male, 3 ft long; M.I. code 43125-046.

Chapter 2

Operation

2.1 PREPARATION FOR USE

As protection against the hazard of shocks in transit, the tuning drive is turned to the high frequency end of the tuning scale and the transit brake applied. You are recommended to take the same precautions when the instrument is transported in future.

In common with other apparatus employing semiconductor devices, the performance of the instrument may be affected if it is subjected to excessive temperatures. Therefore completely remove the plastic cover, if one is supplied over the case, and avoid using the instrument standing on, or close to, other equipment that is hot.

A.C. power supply

Normally the instrument is supplied with the mains selector switch set for supply voltages within the range 190 to 264 V. For input voltages in the range 95 to 130 V the selector switch must be pressed to the left. Do this by removing the plate securing the switch button, pressing the switch to the correct position, reversing the plate and replacing it to hold the switch in the new position. Ensure the mains fuse is 160 mA time-lag on the 240 V range and 250 mA time-lag on the 110 V range.

Attach a suitable 3 pin plug to the mains lead. Note the wires will be colour coded according to the following scheme :

Earth (ground)	-	Green/Yellow
Neutral	-	Light Blue
Line (phase)	-	Brown

In addition the earth wire carries a yellow sleeve bearing a green earth symbol and the neutral wire has a sleeve marked N.

2.2 CONTROLS

(1) MAIN TUNING SCALE : Calibrated at 1 MHz intervals.

(2) MAIN TUNING DRIVE : 28-turn coarse control with 9-turn slow motion drive.

(3) TRANSIT BRAKE : Locks tuning drive during transit. Before applying the brake turn to the high frequency end of the tuning scale.

(4) SUPPLY ON : Pilot lamp indicates presence of supply on primary of mains transformer.

(5) CARRIER DETUNE : Shifts output frequency by approx. 100 kHz.

(6) MODULATION ON/OFF : Switches both internal and external modulation and h.t. to the modulation oscillator.

(7) MODULATION SELECTOR : Selects internal 300 Hz to 3 kHz oscillator or external drive applied to rear panel socket.

(8) F.M. RANGE : Selects the full-scale values of the DEVIATION control dial.

(9) Δ F RANGE : Selects the full-scale values of the Δ F control dial.

(10) FINE TUNE : Useful for peaking the main tuning over a range of about 20 kHz.

(11) EXTERNAL FINE TUNE INPUT : An external voltage from a low impedance source will override the internal fine tune setting. About 1 V d.c. gives a shift of about 20 kHz.

(12) OUTPUT LEVEL : Cursor indicates source e.m.f. Scaled in voltage units and in decibels relative to 1 μV. Calibration valid only when CARRIER LEVEL meter is at the reference mark.

(13) DEVIATION CONTROL : Indicates peak deviation on scale selected by F.M. RANGE switch. Calibration is valid only when MODULATION LEVEL meter is at the reference mark.

(14) ΔF CONTROL : Indicates positive and negative carrier shift on scale selected by ΔF RANGE switch.

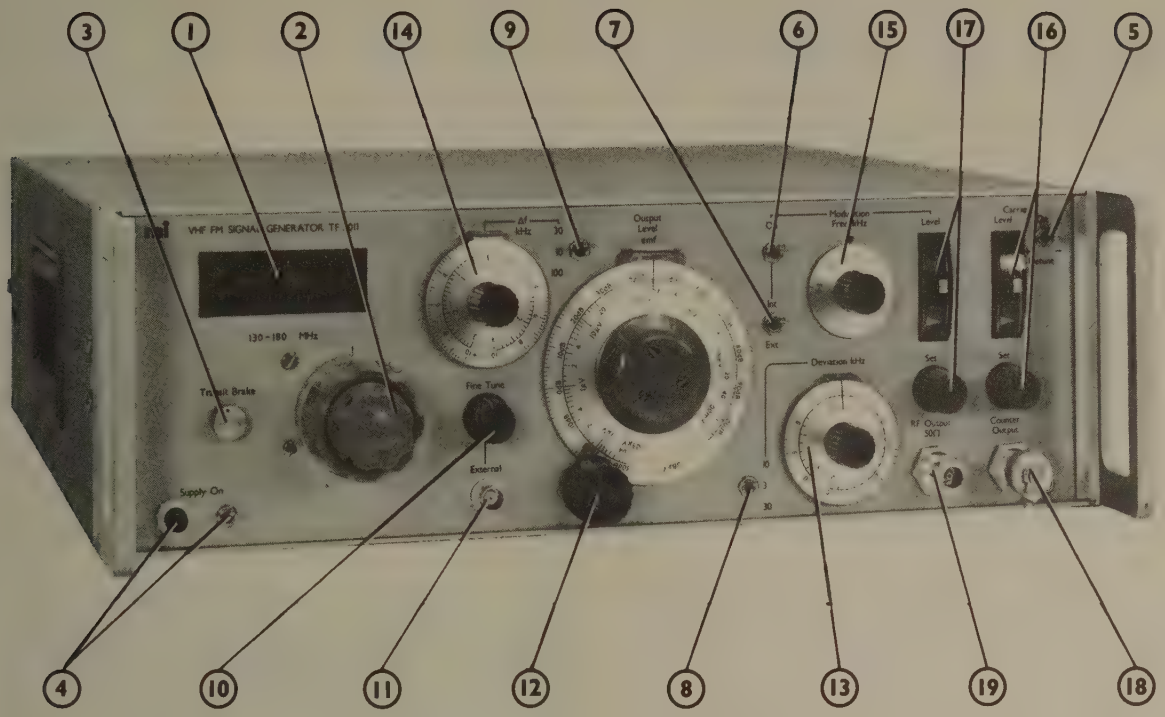


Fig. 2.1 Controls

(15) MODULATION FREQUENCY : Controls frequency of internal modulation oscillator.

(16) SET CARRIER LEVEL : Controls and indicates reference input level to the OUTPUT LEVEL attenuator. Adjust for a meter reading at the reference mark when setting the output.

(17) SET MODULATION : Controls and indicates reference input level to the DEVIATION range circuit. Adjust for a meter reading at the reference mark when setting deviation.

(18) COUNTER OUTPUT : Fixed level output from type N 50 Ω socket. Useful for monitoring generator frequency.

NOTE. When using the R. F. OUTPUT at low level fit the cap to the COUNTER OUTPUT socket or use double screened cable to prevent radiation.

(19) R. F. OUTPUT : Type N 50 Ω socket.

Rear panel connectors

EXTERNAL MODULATION INPUT : 600 Ω inlet for use with external modulating signal between 30 Hz and 15 kHz. Requires 1.5 V r.m.s. for maximum deviation.

MODULATION DRIVE OUTPUT : Provides a monitor for the a.c. and d.c. drive.

MODULATION OSCILLATOR OUTPUT : Provides an output from the internal oscillator at a fixed level of 700 mV e.m.f. from 10 kΩ. Useful as a sync or horizontal drive signal to external viewing equipment.

FUSE : Protects line input to mains transformer. Use time lag type, 160 mA for 230 V working or 250 mA for 110 V working.

2.3 C.W. OPERATION

(1) Turn the CARRIER DETUNE switch to ON. By use of the main tuning drive coarse control and slow motion drive, tune for the required carrier frequency on the main tuning scale.

If a more accurate carrier frequency is required, connect a counter such as the M.I. TF 2410 with TM 8334 600 MHz Converter plug-in to the COUNTER OUTPUT socket. Set the converter to about the required frequency and set the tuning drive coarse control and slow motion drive on the TF 2011 to within about 20 kHz of the required frequency. Then, by adjustment of the FINE TUNE control, set up the signal generator to the required frequency, monitored by the counter.

(2) Select the required level (between 0.03 μV and 200 mV e.m.f.) on the OUTPUT LEVEL attenuator.

(3) Adjust the SET CARRIER control to give a reading on the datum line of the CARRIER LEVEL meter.

An unmodulated r.f. output of the required frequency and amplitude is now obtainable from the r.f. output socket.

2.4 INTERNAL F.M. OPERATION

(1) Set up the required carrier frequency and amplitude as shown in Sect. 2.3. For the best f.m. accuracy the ΔF control must be close to zero.

(2) Switch the MODULATION SELECTOR switch to INT and the MODULATION ON/OFF switch to ON.

(3) Set the MODULATION FREQUENCY dial to the required modulating frequency.

(4) Set the F.M. RANGE switch to the range in which the required deviation falls.

(5) Adjust the SET MODULATION control to give a reading on the datum line of the MODULATION LEVEL meter.

(6) Adjust the DEVIATION control to set up the required value of peak deviation frequency.

An internal frequency modulated r.f. output of the required frequency and amplitude is now obtainable from the R.F. OUTPUT socket.

2.5 EXTERNAL F.M. OPERATION

(1) Set up the required frequency and amplitude of the carrier as shown in Sect. 2.3.

(2) Connect the external modulating source to the EXT input on the rear panel. The external modulating source should be between 30 Hz and 15 kHz in frequency and of amplitude about 1.5 V r.m.s. for maximum deviation.

(3) Switch the MODULATION ON/OFF switch ON and the MODULATION SELECTOR to EXT.

(4) Set the F.M. RANGE switch to the range in which the required deviation falls.

(5) Adjust the SET MODULATION control to give a reading on the datum line of the MODULATION LEVEL meter.

(6) Adjust the DEVIATION control to set up the required deviation.

An external frequency modulated r.f. output of the required frequency and amplitude is now obtainable from the r.f. output socket.

2.6 Δ F OPERATION

The most common function of the ΔF CONTROL is for the measurement of bandwidth. The following procedure outlines the principles of operation for setting up of the Δf controls and measurements of bandwidth using this facility. Both positive and negative frequency increments can be obtained up to a shift of 100 kHz.

(1) Set up the required frequency and amplitude of the carrier as shown in Section 2.3.

(2) Switch the ΔF RANGE switch to the required range.

(3) Set the Δ F CONTROL to give the required frequency shift. The output can be obtained from the r.f. output socket.

NOTE. When the carrier is required to be interrupted the CARRIER DETUNE switch may be used. If the signal generator is tuned to the lower sideband of the instrument under test switch the

CARRIER DETUNE switch to DETUNE–, and when it is tuned to the upper sideband of the instrument under test switch the CARRIER DETUNE switch to DETUNE+. This gives approximately ±100 kHz shift from the carrier frequency.

2.7 SETTING OUTPUT

The level at the R. F. OUTPUT socket is given by the reading of the attenuator scale as an e.m.f. from a 50 Ω source. The scale is calibrated in voltage units as well as in dB relative to 1 μV.

To find the voltage developed across a load, it is necessary to know the load impedance.

The voltage (V_L) developed across a load of impedance (Z_L) is given by :

$$V_L = E \frac{Z_L}{50 + Z_L}$$

where E is the indicated source e.m.f.

Table 2.1 shows the conversion factors for obtaining the load voltage from the indicated e.m.f. at different load impedances.

Table 2.1

To find load voltage:

Load ohms	Multiply e.m.f. by	or subtract dB
10	0.167	15.5
20	0.286	10.9
30	0.375	8.5
40	0.445	7.0
50	0.50	6.0
60	0.55	5.2
70	0.58	4.7
75	0.60	4.4
80	0.62	4.2
90	0.64	3.8
100	0.67	3.5
120	0.71	3.0
150	0.75	2.5
200	0.80	1.9
300	0.86	1.3
500	0.91	0.8
600	0.92	0.7
800	0.94	0.5
1000	0.95	0.4
2000	0.98	0.2
4000	0.99	0.1

Chapter 3

Technical description

Each of the printed boards and other sub-assemblies in this instrument has been allocated a unit identification number in the sequence 1 to 9. The complete circuit reference for a component carries its unit number as a prefix e.g. 3R14. Components that do not form part of any sub-assembly carry the prefix 0 e.g. 0R7.

For convenience in this chapter and on the circuit diagrams, the circuit reference is abbreviated by dropping the prefix, except where there is risk of ambiguity.

3.1 MODULATION OSCILLATOR (Unit 3)

This oscillator is a simple Wien Bridge oscillator designed to cover only the most relevant frequency decade, i.e. the speech band of 0.3 to 3.0 kHz. The series elements of the bridge are R14 in series with the parallel combination of C4, C6 and C8. The shunt elements are R5 in parallel with C7 and C9.

The capacitors C6, C7, C8 and C9 are provided by a solid dielectric tuning gang. Thermistor R12 provides the level stabilizing feedback.

A field effect transistor, TR1, is used to provide the high input impedance necessary for compatibility with the Wien Bridge components. Resistor R16 in series with the output components of the oscillator, pads the impedance to 600 Ω. The output e.m.f. level is 0.7 V. An external modulation facility is provided via the external modulation input on the back panel; when external modulation is selected by the modulation selector switch, the internal modulation oscillator continues to run. A modulation on/off switch is also provided, which interrupts the feed to the f.m. drive amplifier and switches the internal modulation oscillator off.

3.2 F.M. DRIVE AMPLIFIER (Unit 5)

The function of the f.m. drive amplifier is to amplify the signal from the modulation oscillator. The set modulation potentiometer, 0R3, acts as a potential divider on the input of the amplifier, adjusting the level of modulating signal to the standard level, indicated by the modulation meter, at which the calibration of the deviation controls applies. The amplifier circuit is a complementary feedback circuit, feedback being provided via R6. The two transistors are biased by R3 and R4, and C2 provides the a.c. coupling to the deviation controls.

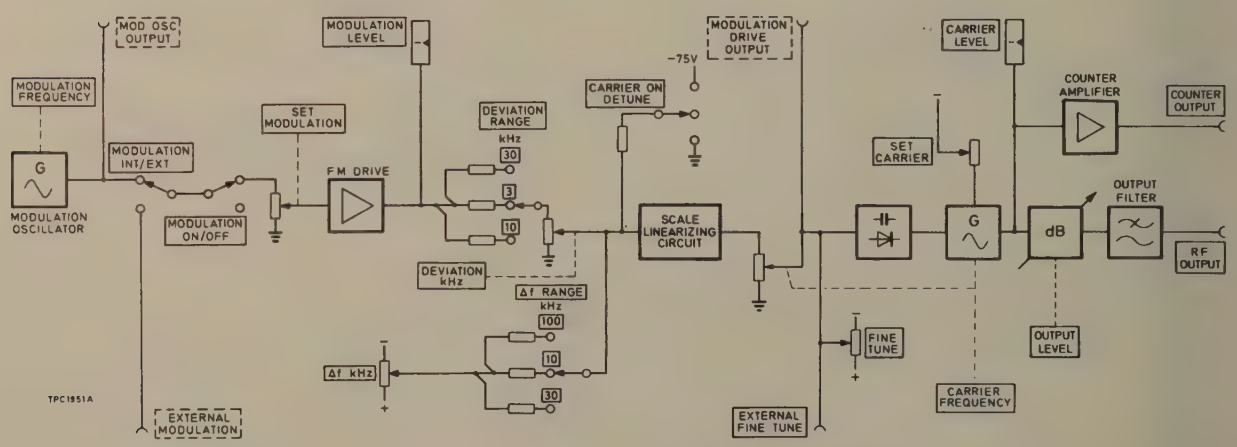


Fig. 3.1 Block diagram

3.3 DEVIATION CONTROLS

Deviation is provided in three ranges 3, 10 and 30 kHz by switch S5. Series resistors are used in order to set the correct value of deviation on each range. Resistors R9 and R22 are in circuit on all 3 ranges but on the 30 kHz range they are short circuited. On the 10 kHz range they are shunted by R8 and R21, and the 3 kHz range uses them alone. R22 and R21 are variable and adjust the 3 kHz and 20 kHz deviation ranges respectively. The deviation control 0R4 is a potential divider and is continuously variable via the front panel control.

3.4 Δ F CONTROLS (Unit 4)

The Δ f controls provide a d.c. bias to the varactor diode 7D2, hence providing a change in frequency of the r.f. oscillator. Three ranges 10 kHz, 30 kHz and 100 kHz are provided, the required voltage for each being obtained from the -75 V supply via potentiometer 0R5, which provides the Δ f control on the front panel, and the range resistors. Preset potentiometers R14, R15 and R16 provide the required Δ f accuracy adjusting the 10 kHz, 30 kHz and 100 kHz ranges respectively.

3.5 DEVIATION AND Δ F SCALE LINEARIZATION AND TRACKING

A scale linearizing circuit is incorporated in order to compensate for non-linearity due to the characteristics of the varactor diode modulator. Diode 4D1, in conjunction with the potential divider R14, R15 determine the value of f at which the compensation takes effect. The amount of compensation required is controlled by 4R13.

Because the sensitivity of the varactor modulator varies with carrier frequency, a tracking system is necessary to provide the correct amount of drive. This function is provided by the tracking network, unit 8, consisting of a potentiometer coupled to the oscillator tuning drive mechanism. The potentiometer, R12, is tapped at sixteen points and each tap connected to one of sixteen taps on a resistive potential divider across which the modulating signal is applied.

3.6 MODULATION MONITOR (Unit 5)

The output from the f.m. drive amplifier is sampled by diodes D1 and D2 which act as a peak-to-peak detector. The meter circuit suppresses indication of low level signals. Bias for TR3 is derived from R10, R23 and R11; it is set so that under no signal conditions the emitter of TR3 is more negative than the junction of R14/16. Under these conditions D3 is reverse biased and no current flows through the meter. With high inputs the emitter of TR3 follows the base in a positive-going direction, turning on D3 and allowing the meter to indicate. Thermistor R26 provides compensation for drift caused by thermal effects in the diodes and the transistor.

3.7 CARRIER LEVEL MONITOR

The carrier level monitor pick-up is mounted in the r.f. oscillator casting. R.F. is developed across the coil and is half-wave detected by 7D1. Forward current bias is derived via 5R18 and 5R19 and the meter is returned to a similar resistor and diode chain to ensure balance under all conditions. 5R24 is the zero balance resistor ensuring that a null can be obtained in the detecting arm. The sensitivity preset control, 5R25, is connected in series with the meter.

3.8 FINE TUNING

The varactor diode may also be utilized by applying a d.c. potential to it. The fine tuning controls provide up to 1.2 V d.c. from the -18 V supply line via resistors 4R20, 0R6, 0R13 and 0R10. An external fine tune input is also available, bypassing these three resistors.

3.9 R.F. OSCILLATOR

The oscillator assembly consists of two castings bolted together carrying in various compartments the oscillatory circuit, modulating circuit, counter output amplifier and filter circuits.

To achieve good freedom from microphonic modulation the tuning capacitor, 7C27, is constructed in the form of a plunger with a hole which mates

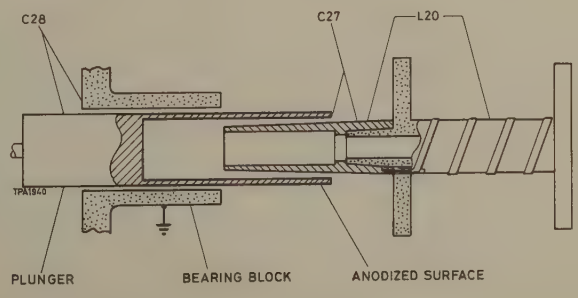


Fig. 3.2 Tuning components of the r.f. oscillator

with a corresponding tapered end of the tuning inductor. The plunger slides in an earthed bearing block forming a capacitor, 7C28, to earth. The dielectric for this capacitor is the aluminium oxide layer produced by anodizing the plunger.

As the plunger moves in and out both the spacing between it and the fixed part of the capacitor, as well as their overlap, varies giving a square law capacitance change and consequently a near linear frequency law.

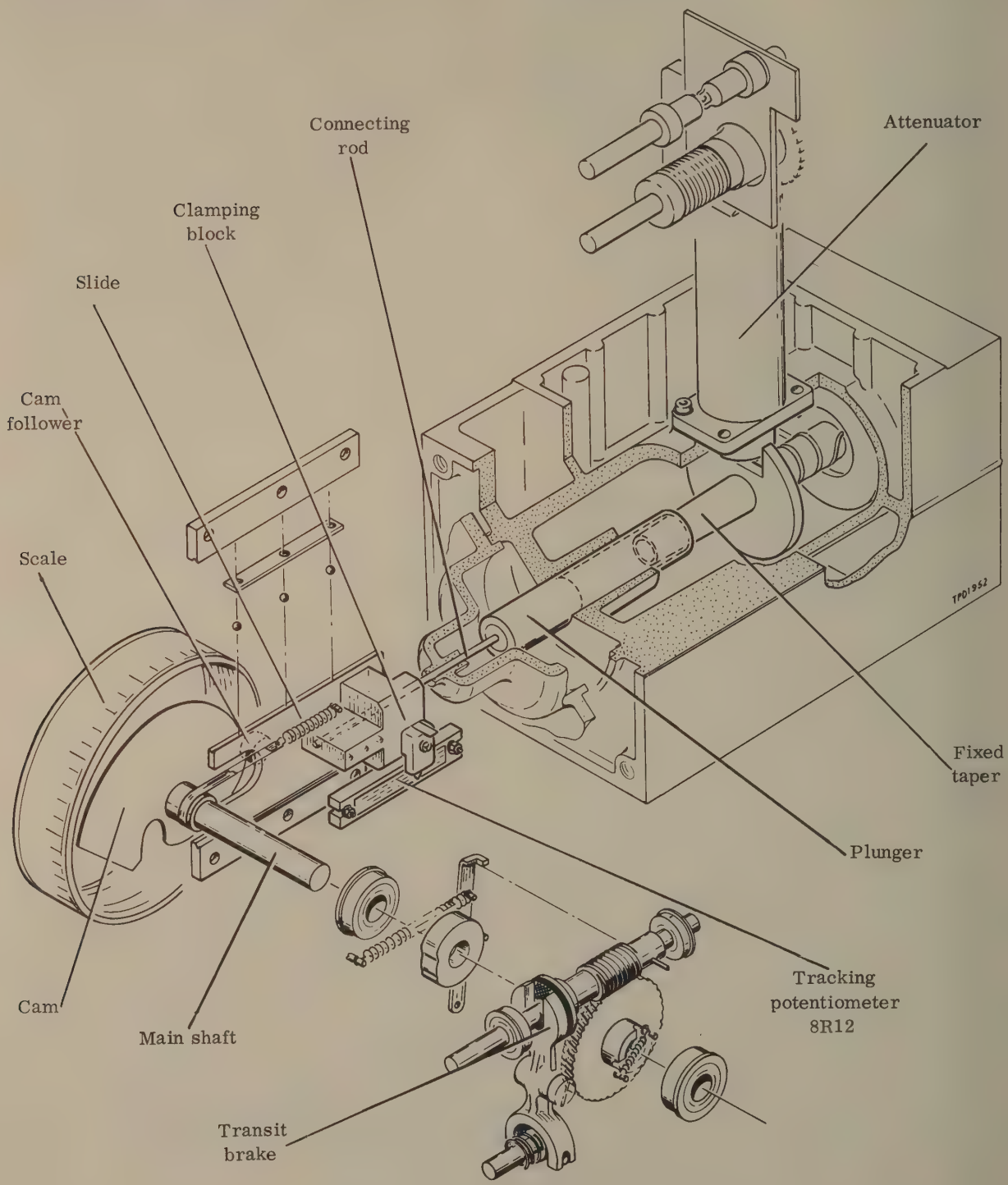


Fig. 3.3 Exploded view of oscillator with front section of casting omitted

The r.f. oscillator circuit is of the Clapp configuration. The circuit is driven by a grounded-grid Nuvistor valve whose tuned circuit comprises three capacitors 7C26, 7C27 and 7C28 of which 7C27 is the main tuning capacitor. 7L20, the main tuning inductor which is in series with the tuning capacitors, is effectively a $\lambda/2$ line which mates with the plunger. The anode to cathode feedback is provided by 7C23 which is a preset capacitor of value 0.5 - 5 pF. Bias is applied to the valve by capacitor 7C25 and grid leak resistor 7R3 which form a leaky grid bias circuit thereby providing amplitude stabilization. 7L18 and 7L19 are r.f. chokes which provide conducting return paths for the d.c.

In order to provide greater frequency stability, a CARRIER DETUNE facility is provided which will shift the carrier frequency by approximately ±100 kHz thereby eliminating the necessity of switching off the r.f. oscillator supply when interrupting the carrier. By allowing a constant current to flow through V1 it is ensured that the valve does not cool down and subsequently cause drift.

The counter amplifier is of conventional configuration. It is a two stage r.c. coupled amplifier, its input being taken via a loop from the r.f. oscillator. Resistors 6R1 and 6R2 provide the bias for 6TR1 whilst 6R5 and 6R6 provide the bias for 6TR2.

The modulator is also mounted in the r.f. oscillator casting, the varactor diode being connected in parallel with the tuned circuit. The capacitance of the varactor varies with the voltage applied to it hence producing deviation from the carrier frequency. The deviation and Δf scale linearizer operates in conjunction with the modulator, predistorting the modulating signal, compensating for the non-linearity of the varactor diode.

All inputs to and outputs from the r.f. oscillator casting are made via low-pass filters whose purpose is to reduce leakage.

3.10 ATTENUATOR

The piston attenuator is bolted to the side of the r.f. oscillator casting and acts as a continuation of the cavity containing the oscillator tuned circuit. The position of the piston in the attenuator, which is set by a front panel control, thus provides a means of controlling the output level. The attenuator piston is in the form of a plunger attached to a rack. The rack is driven by reduction gearing from the attenuator control via a shaft with flexible couplings. A return shaft driven directly by the rack drives the attenuator scale.

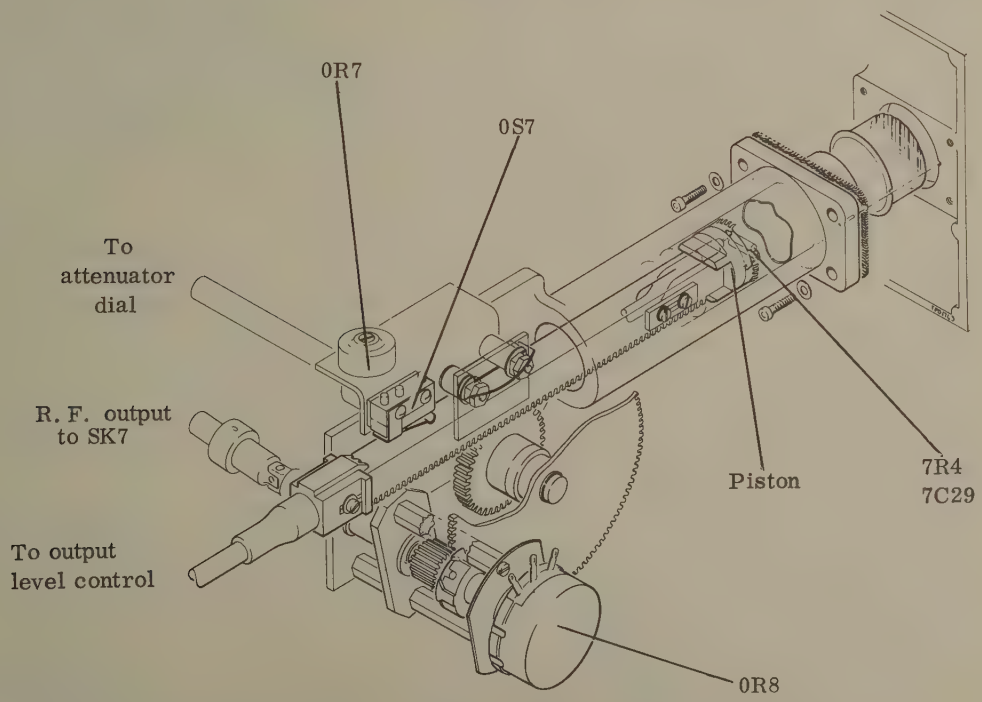


Fig. 3.4 Attenuator

The attenuator reaction at the high level end of the attenuator is compensated by resistor R8 which is coupled to the attenuator drive shaft. Over the last half inch of the travel of the attenuator the microswitch, 0S7, which is in parallel with 0R8, is open circuited and 0R8 is brought into circuit.

3.11 POWER SUPPLY

The mains transformer, T1, has two secondaries. The first produces the -75 V supply for the r.f. oscillator valve and the second provides a -6.3 V and -18 V supply for the valve heater and for the transistor supply respectively.

The -75 V unit comprises a full-wave rectifier diode bridge circuit consisting of 4 diodes, 1D1-4. Zener diode, 1D5, provides the voltage reference for the circuit. Resistors 1R10, 1R11 and 1R12 sample the output voltage and any error signal is applied to the error amplifier 1TR3 and 1TR1 on the supply board and thence to the series control transistor 1TR2. Overload protection is obtained by 1R3 and 1TR4. When more voltage is dropped across 1R3, 1TR4 is turned on placing a low impedance between the base and emitter of TR2 and turning it off. The output comprises a four line system, two of which carry the supply and two of which sample the signal at an h.t. point. Resistors 1R9 and 1R10 provide alternative sampling points if the load circuit is disconnected.

The -18 V power unit is similar in design to the -75 V power unit. The -6.3 V supply is taken from the negative side of electrolytic capacitor 2C4, via resistor 2R8. The -18 V output may be adjusted by 2R12.

Chapter 4

Maintenance

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and for checking its overall performance.

Before attempting any maintenance on the signal generator, you are advised to read the preceding Technical Description chapter.

CAUTION

This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as reversal of batteries, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistors.

4.2 SCREW FASTENERS

Screw threads used on this instrument are of the following sizes: 2 BA, 4 BA, 6 BA on the r.f. oscillator, the piston attenuator and their drive units and ISO M3, 4 and 5 on the main chassis. All ISO metric screws are tinted blue for easy identification.

Do not replace ISO metric screws with BA, BSF, BSW or unified screw sizes.

4.3 REMOVAL OF CASE

To remove the outer case of the instrument extract the four M4 screws at the side of the instrument (two on each side). The top panel may now be lifted off, giving access to all the sub-assemblies.

4.4 LOCATION OF SUB-ASSEMBLIES

All of the printed boards on the instrument are immediately accessible except the counter amplifier which is mounted inside the r.f. oscillator box.

The back plate of the r.f. oscillator box may be removed by extracting twelve 6 BA screws. This will make the counter amplifier board, V1, and its surrounding components accessible.

Layout illustrations of the counter amplifier board and the components of the r.f. oscillator are given in chapter 5, Figs 5.1 and 5.2. Mechanical components of the attenuator and oscillator assembly are shown in Figs 3.3 and 3.4.

4.5 CIRCUIT VOLTAGES

The voltages given on the circuit diagrams are those which may be expected on a typical TF 2011 at a mains input of 240 V, using a 20 kΩ/V meter. All are negative with respect to the positive supply line.

The controls were set to the following positions:

SUPPLY switch	ON
Main tuning dial	150 MHz
Δ F (kHz) switch	30 kHz
Δ F (kHz) control	0
FINE TUNE control	clockwise
OUTPUT LEVEL control	10 μV
MODULATION ON/OFF switch	ON
MODULATION SELECTOR	INT

DEVIATION control	3
MODULATION FREQUENCY control	1 kHz
F.M. RANGE switch	30 kHz
MODULATION LEVEL meter SET MODULATION control	at datum line
CARRIER LEVEL meter SET CARRIER control	at datum line

4.6 CLEANING AND LUBRICATION

Rotary switches

If it is necessary to clean the contacts of any of the rotary switches, this should be done with white spirit (not carbon tetrachloride), and the contacts should afterwards be wiped with a suitable lubricant such as a 5% solution of petroleum jelly in white spirit. Avoid lubricants containing soap or solid materials.

R.F. units

The plunger of the oscillator tuning capacitors is dry lubricated during manufacture with molybdenum disulphide powder. Under no circumstances should any other lubricant be used.

Relubrication of the r.f. drives is only likely to be required at infrequent intervals. When, however, it is needed a little Albaline may be applied to slide bearings and a little molybdenum disulphide grease to the worm and worm wheel.

Attenuator

The attenuator rack and front panel drive assembly is lubricated during manufacture. Relubrication is only likely to be required at infrequent intervals. When, however, it is needed a little Aeroshell 14 may be applied to these parts.

4.7 PERFORMANCE CHECKS

The tests in this section may be used as a routine maintenance procedure to verify the main performance parameters of the instrument. All tests can be completed without removing the case, except where some internal readjustment is indicated.

4.7.1 Test equipment required

See Table 4.1

4.7.2 Frequency calibration accuracy

Test equipment : item a.

Connect the counter output of the TF 2011 to input B on the converter unit. Adjust the set carrier level control on the TF 2011 to give a deflection on the datum line of the carrier level meter. Check at 5 MHz intervals throughout the band, that the frequency calibration accuracy is within ±1.0%.

4.7.3 Attenuator reaction

Test equipment : items a, m.

Connect the counter output of the TF 2011 to input B on the converter unit and the 50 Ω load to the r.f. output of the TF 2011. Adjust the set carrier level control to give a deflection to the datum line of the carrier level meter. Adjust the attenuator on the TF 2011 to the 80 dB μV position and adjust the main tuning control to about 150 MHz and note the exact frequency indicated by the counter/converter.

Adjust the attenuator steps from 80 dB μV to 104 dB μV, ensuring that the frequency control is not adjusted. Check that the attenuator reaction does not cause a frequency shift of more than ±2 kHz from the frequency recorded with the attenuator set to 80 dB μV. If adjustment is required follow the procedure in section 5.3.9.

4.7.4 Attenuator accuracy

Test equipment : items b, c, d, m, n.

Connect up the test equipment as shown in Fig. 4.1. Set the output level control to 106 dB μV and adjust the set carrier control until the carrier

Table 4.1

Item	Type	Minimum specification	Recommended model
a	Frequency counter	Input frequency: 130-180 MHz Sensitivity: > 100 mV	TF 2401 with TM 8334 plug-in
b	R. F. millivoltmeter	Frequency range: 130-180 MHz Sensitivity: 100 mV Accuracy: 3%	TF 2603
c	Attenuator	0-100 dB in 1 dB steps Accuracy: 1% (preferably standardized) Frequency range: 130-180 MHz	TF 2163
d	Receiver and 'S' meter	Frequency range: 130-180 MHz Sensitivity: 1 μV	Eddystone 770U
e	Probing loop	Loop of two turns, 1 inch diameter connected to coaxial lead with plug	-
f	Modulation meter	Carrier frequency range: 130-180 MHz Deviation range: up to 30 kHz Accuracy: 3%. Inherent noise produces deviation of less than -70 dB relative to 50 kHz when crystal locked.	TF 2300/2300A
g	A. F. oscillator	Frequency range: 30 Hz - 15 kHz Output level: up to 2 V	TF 1370 or TF 1101
h	Wave analyser	Frequency range: 0-25 kHz Bandwidth: < 6 Hz Accuracy: 1%	TF 2330/2330A
i	A. M. signal generator	Frequency range: 130-180 MHz Modulating frequency: 1 kHz Output: > 200 mV	TF 801D
j	U. H. F. detector	Frequency range: 130-180 MHz Sensitivity: 1 mV/μW R. F. input: N type male	Hewlett Packard 423A
k	Sensitive valve voltmeter	Accuracy: 2% Frequency range: 30 Hz - 15 kHz Sensitivity: >1 mV	TF 2600
l	Psophometer	Accuracy: ±1 dB Telephone and broadcast weighting available Sensitivity: 100 μV	Hatfield Instruments SPO
m	50 Ω load	'N' type connectors	TM 7967
n	Coaxial 'T' connector		TM 7948
o	Crystal oscillator	Frequency 130 MHz	

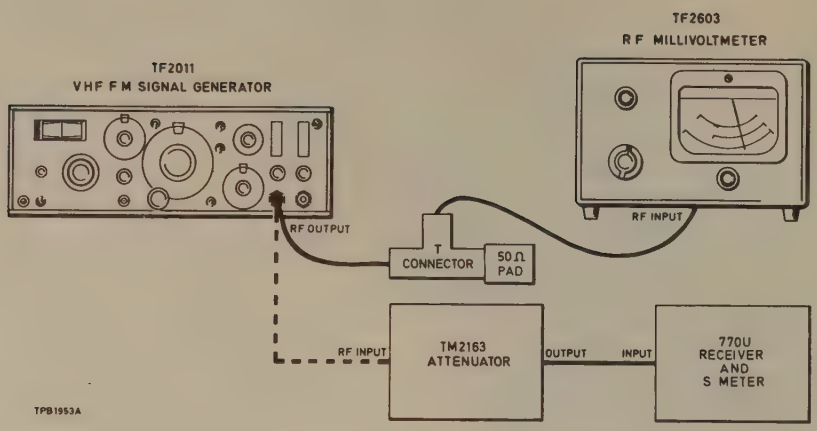


Fig. 4.1 Test gear layout for attenuator accuracy

level meter indication reads on the datum line. Ensure that the r.f. millivoltmeter reads 100 mV within ±1 dB (about ±11%).

Then adjust the output level control on the TF 2011 to read exactly 100 mV on the r.f. millivoltmeter. Without adjusting any of the controls on the TF 2011, disconnect the r.f. millivoltmeter and connect the r.f. output of the TF 2011 to the input of the r.f. attenuator. Set the r.f. attenuator to give 100 dB attenuation allowing for the insertion loss at the frequency used, and connect its output to the input of the receiver and 'S' meter. Tune the receiver to the TF 2011 and adjust the sensitivity control on the receiver so as to read f.s.d. on the 'S' meter. The receiver sensitivity with the 'S' meter at f.s.d. is now 1 μV. Adjust the output level control in 10 dB steps from 106 dB μV to 6 dB μV ensuring that the reading on the r.f. attenuator which is required to keep the 'S' meter at f.s.d. is 6 dB less than the reading on the output level control of the TF 2011 within ±1 dB.

4.7.5 R.F. leakage

Test equipment : items b, c, d, e.

Set the receiver and 'S' meter sensitivity to 1 μV as outlined in the previous test. Disconnect the lead from the r.f. output of the TF 2011 to the input of the receiver. Turn the OUTPUT LEVEL control to give minimum output and put the cap on the COUNTER OUTPUT socket. Connect the test loop to the input of the receiver and ensure that no r.f. leakage is detected at a distance greater than 1 inch from the TF 2011.

4.7.6 Internal deviation accuracy

Test equipment : item f.

Set the TF 2011 controls as follows:

Main tuning dial	150 MHz
Output level control	200 mV e.m.f.
F.M. range	3 kHz
Deviation control	3
Modulation frequency control	1 kHz
Modulation selector	INT
Modulation ON/OFF switch	ON
Carrier detune switch	ON

Ensure that the carrier level meter and the modulation level meter are both set to their datum lines by adjusting the set carrier and set modulation controls.

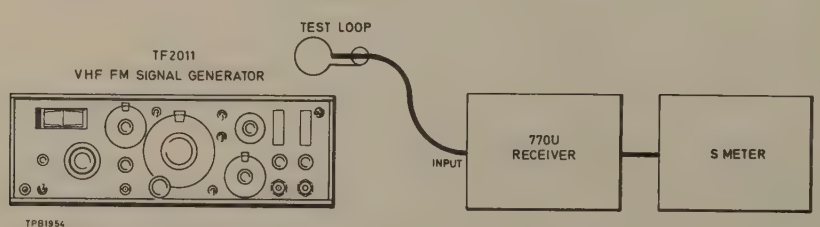


Fig. 4.2 Test gear layout for R.F. leakage

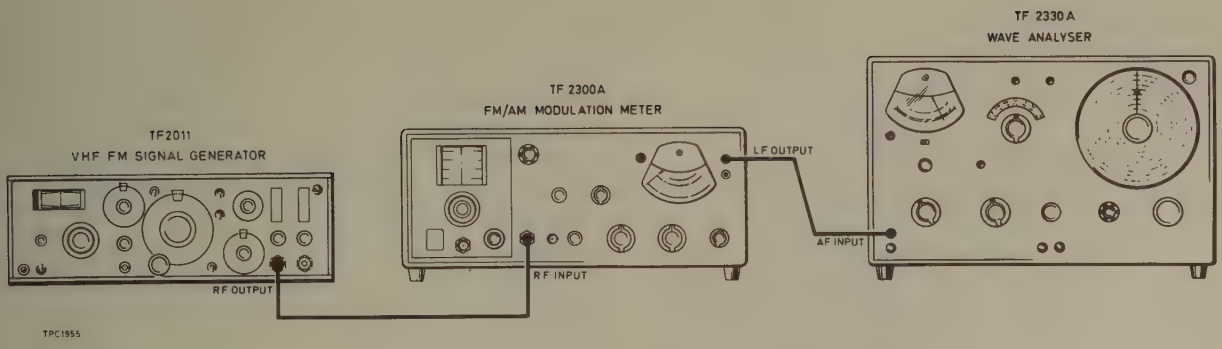


Fig. 4.3 Test gear layout for F.M. distortion

Connect the r.f. output of the TF 2011 to the r.f. input of the modulation meter and measure the deviation. Ensure that the reading obtained is 3 kHz ±6%.

Check that the deviation control on the TF 2011 is accurate within ±6% at f.s.d. on the 10 kHz and 30 kHz deviation ranges.

4.7.7 F.M. distortion

Test equipment : items f, h.

Connect the r.f. output of the TF 2011 to the r.f. input of the modulation meter and the l.f. output of the modulation meter to the a.f. input of the wave analyser. Set the TF 2011 controls as follows:

Main tuning dial	150 MHz
Output level control	200 mV e.m.f.
F.M. range	3 kHz
Deviation control	3
Modulation frequency control	1 kHz
Modulation selector	INT
Modulation ON/OFF switch	ON
Carrier detune switch	ON

Ensure that the carrier level meter and the modulation level meter are both set to their datum lines by adjusting the set carrier and set modulation controls.

Tune the wave analyser to the modulation frequency of the TF 2011 and by adjustment of the set reference control set up a suitable reference point on the wave analyser meter. Tune to the second and third harmonics of the modulation frequency and ensure that the total harmonic distortion is less than 0.75%. Repeat this test at a deviation of 10 kHz, ensuring that f.m. distortion is less than 0.75%. Repeat this test at a deviation of 30 kHz, ensuring the f.m. distortion is less than 1.5%.

4.7.8 External deviation accuracy

Test equipment : items f, g.

Connect the audio oscillator to the external modulation input on the rear panel of the TF 2011. Set the audio oscillator to give an output of about 1.5 V at a frequency of 1 kHz. Set the TF 2011 controls as follows:

Main tuning dial	150 MHz
Output level control	200 mV e.m.f.

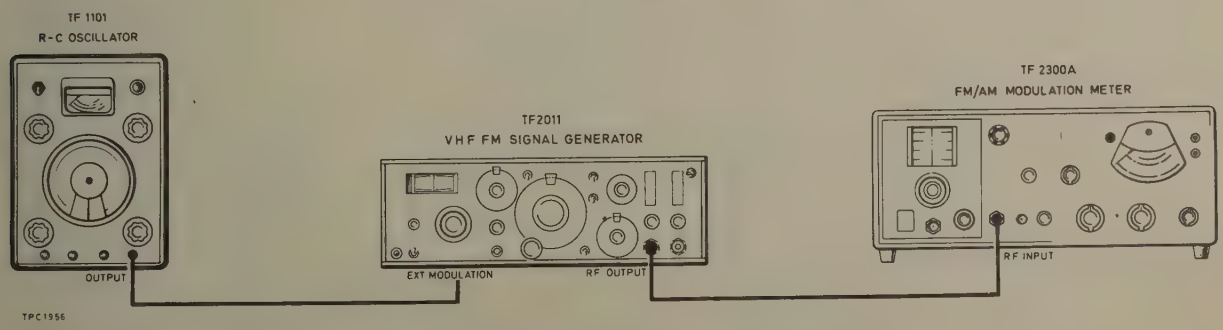


Fig. 4.4 Test gear layout for external deviation accuracy

Carrier detune switch	ON
F.M. range	30 kHz
Deviation control	3
Modulation SELECTOR switch	EXT
Modulation ON/OFF switch	ON

Ensure that the carrier level meter and the modulation level meter are both set to their datum lines. The carrier level meter may be adjusted by the set carrier control and the modulation level meter may be adjusted by the output control on the a.f. oscillator and by the set modulation control.

Connect the r.f. output of the TF 2011 to the r.f. input of the modulation meter and measure the deviation. Ensure that the reading obtained is 30 kHz ±6%.

4.7.9 External f.m. frequency characteristic

Test equipment : items f, g.

Connect up the apparatus as in section 4.7.8 and set the a.f. oscillator to give a reading of 30 kHz deviation frequency on the modulation meter at a modulating frequency of 1 kHz. Ensuring the output level from the a.f. oscillator remains constant adjust the modulating frequency from 30 Hz to 15 kHz. Check that the deviation remains constant at 30 kHz within ±1.0 dB (i.e. from 28.323 kHz to 33.66 kHz).

4.7.10 A.M. on f.m.

Test equipment : items g, i, j, k.

Set up the apparatus as shown in Fig. 4.5.

Adjust the a.f. oscillator to give an output of about 1 V at a frequency of 1 kHz. Set the a.m. signal generator to 500 MHz with an output level of 100 mV as indicated on the output attenuator with the carrier level meter at set carrier. Adjust the audio source output level until 30% modulation is indicated on the % modulation meter on the a.m. signal generator. Note the valve voltmeter reading.

Repeat this check at 10% and 20% modulation, to confirm that the detector has a linear characteristic.

Replace the audio source and the a.m. signal generator with the TF 2011 with its controls set to the following positions:

Main tuning dial	500 MHz
Output level control	100 mV
F.M. range	30 kHz
Deviation control	3
Modulation frequency control	1 kHz

Ensure the carrier level meter and the modulation level meter are both set to their datum lines by adjusting the set carrier and set modulation controls.

Ensure that for 30 kHz deviation the spurious a.m. does not exceed 0.5% modulation.

i.e. spurious a.m. is less than

$$\frac{\text{valve voltmeter reading for 30\% modulation}}{60}$$

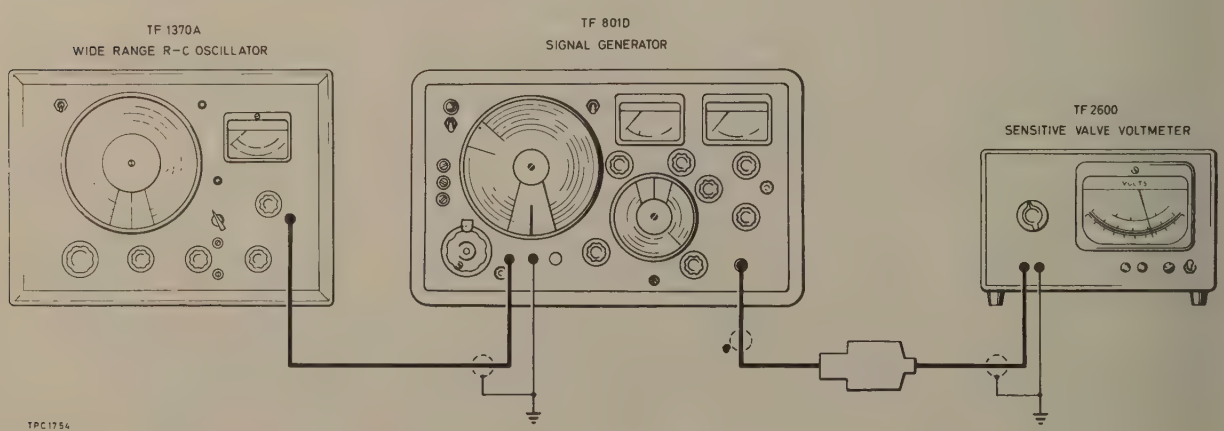


Fig. 4.5 Test gear layout for external f.m. frequency characteristic

4.7.11 F.M. noise

Test equipment : items f, l.

Connect the r.f. output of the TF 2011 to the r.f. input of the modulation meter and the l.f. output of the modulation meter to the input of the psophometer. Set the psophometer controls as follows :

Input conditions	terminated
Weighting	telephone
Attenuator	0 dB

Set the TF 2011 controls as follows :

Main frequency dial	150 MHz
Output level	100 mV e.m.f.
Modulation selector switch	INT
Carrier detune switch	ON
Modulation ON/OFF switch	ON
Deviation control	5
F.M. range	10 kHz
Modulation frequency control	1 kHz

Ensure the carrier level meter and the modulation level meter are both set to their datum lines by adjusting the set carrier and set modulation controls.

Set the modulation meter to 15 kHz maximum deviation and crystal lock the incoming signal. Make a note of the dB reading on the psophometer.

Turn the modulation on/off switch on the TF 2011 to OFF and make a note of the dB reading on the psophometer is at least 64 dB. (i.e. 3 Hz f.m. noise.)

Repeat this test with the psophometer weighting control set to broadcast with a modulating frequency of 1 kHz, and ensure that the difference in readings on the psophometer is at least 54 dB. (i.e. 10 Hz f.m. noise.)

4.7.12 Sideband noise

Test equipment : items a, h, m, n, o.

The method of test used during manufacture requires special purpose test equipment which is not generally available. The following procedure is a simplified version of the factory method.

Set the TF 2011 to give an output of 200 mV at 130 MHz. Beat the TF 2011 output against the 130 MHz reference frequency provided by the crystal oscillator in order to obtain a 25 kHz difference frequency as monitored on the counter. Tune the wave analyser to various frequencies between 15 kHz and 25 kHz noting the level obtained at each frequency.

It is not possible to make direct measurement at the specified point, 20 kHz from the carrier, but an indication of satisfactory performance would be given by a level of about 90 dB down at 24 kHz (1 kHz from carrier) and about 115 dB down at 20 kHz (5 kHz from carrier).

NOTE. These measurements are for a 6 Hz bandwidth, the corresponding levels for 1 Hz are $\sqrt{6}$ times or 8 dB lower.

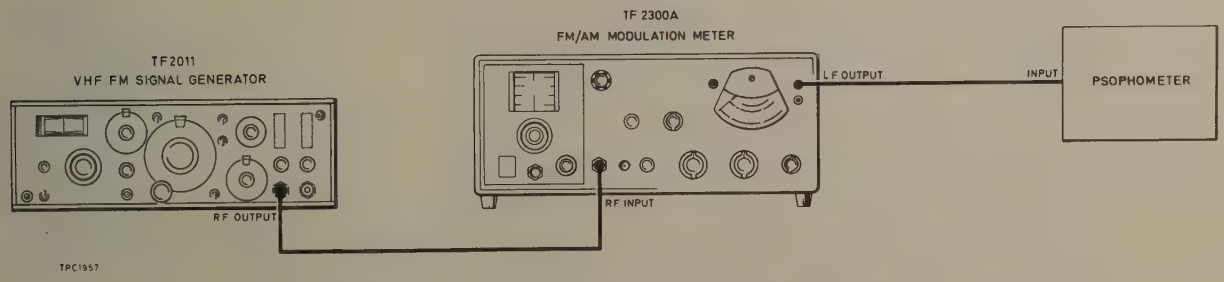


Fig. 4.6 Test gear layout for f.m. noise

4.7.13 Modulation oscillator accuracy

Test equipment : item a.

Connect the modulation oscillator output on the rear panel of the TF 2011 to input A on the counter. Set the controls on the TF 2011 as follows:

Modulation ON/OFF switch	ON
Modulation selector switch	INT
Modulation frequency control	300 Hz

Monitor the modulation frequency on the counter and ensure that it is 300 Hz ±10%.

Repeat the test at modulation frequencies of 1 kHz and 3 kHz.

4.7.14 Modulator oscillator distortion

Test equipment : item p.

Connect the modulation oscillator output on the rear panel of the TF 2011 to the input of the distortion factor meter. Set the TF 2011 controls as follows:

Modulation ON/OFF switch	ON
Modulation selector switch	INT
Modulation frequency control	300 Hz

By use of the distortion factor meter ensure that the total harmonic distortion does not exceed 0.25%.

Repeat the test at modulation frequencies of 1 kHz and 3 kHz.

Chapter 5

Repair

5.1 GENERAL

This chapter is intended to help users fault find, carry out internal checks, make minor adjustments and realign circuits, used in conjunction with the circuit diagrams at the rear of this manual. Performance limits quoted are for guidance only and should not be taken as guaranteed performance specifications unless they are also quoted in the Data Summary. Details of case removal and access to printed boards are explained in Chapter 4.

CAUTION

See Sect. 4.1 for precautions in handling semiconductors and Sect. 4.2 for advice on screw fasteners.

In case of any difficulty, please write to or phone the Marconi Instruments Service Division (see address on back cover) or your nearest representative, quoting the type and serial number on the data plate at the rear of the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

5.2 FAULT LOCATION

Tables 5.1 and 5.2 are fault location charts which should enable the user to systematically trace a fault to any one particular part of the instrument. The charts should be used on conjunction with the circuit diagrams and the static voltages given on the diagrams.

Table 5.1 Fault location on the c.w. path

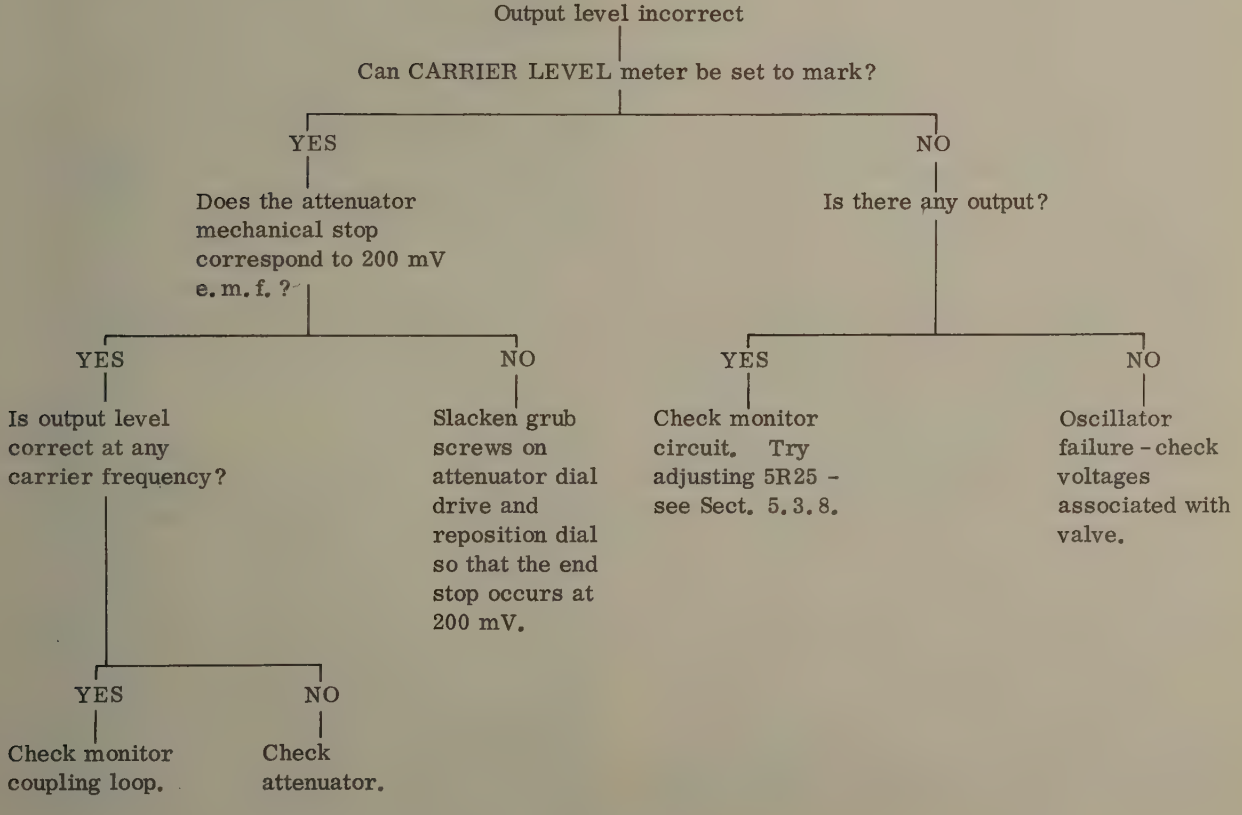
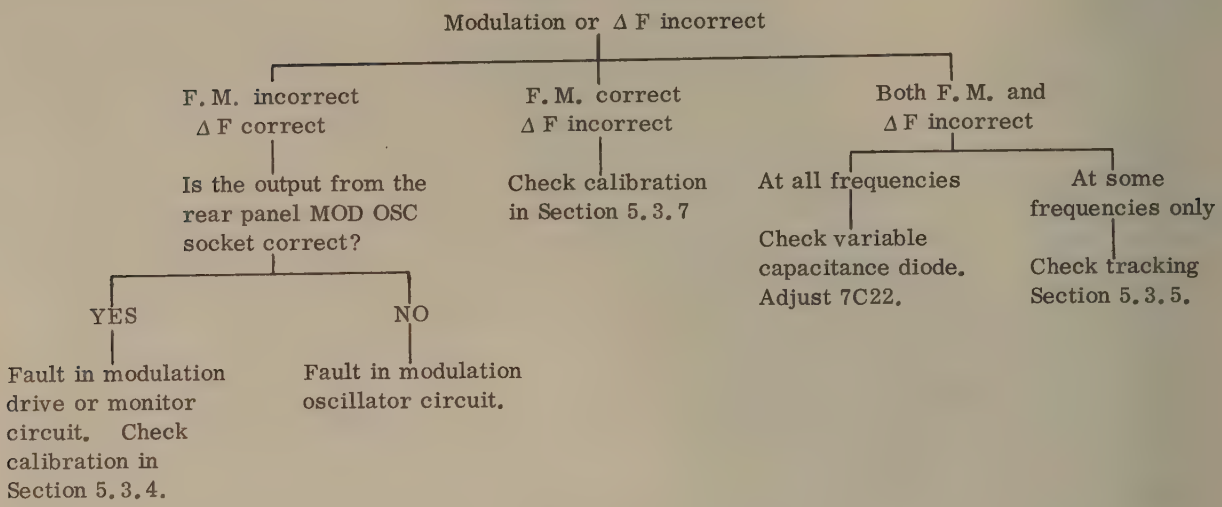

Output level incorrect
Can CARRIER LEVEL meter be set to mark?
YES
NO
Does the attenuator mechanical stop correspond to 200 mV e.m.f.?
Is there any output?
YES
NO
YES
NO
Is output level correct at any carrier frequency?
Slacken grub screws on attenuator dial drive and reposition dial so that the end stop occurs at 200 mV.
Check monitor circuit. Try adjusting 5R25 - see Sect. 5.3.8.
Oscillator failure - check voltages associated with valve.
YES
NO
Check monitor coupling loop.
Check attenuator.

Table 5.2 Deviation, Δ f and fine tune fault location chart


Modulation or Δ F incorrect
F. M. incorrect
Δ F correct
F. M. correct
Δ F incorrect
Both F. M. and
Δ F incorrect
Is the output from the rear panel MOD OSC socket correct?
Check calibration in Section 5.3.7
At all frequencies
At some frequencies only
Check variable capacitance diode. Adjust 7C22.
Check tracking Section 5.3.5.
YES
NO
Fault in modulation drive or monitor circuit. Check calibration in Section 5.3.4.
Fault in modulation oscillator circuit.

If any power supply malfunction is suspected due to fuses blowing or the pilot lamp not becoming illuminated etc. it should be corrected before continuing with the fault finding charts.

5.3 RECALIBRATION

5.3.1 Test equipment required

(a) Multimeter

(b) Frequency counter e.g. M.I. type TF 2410

(c) Frequency converter e.g. M.I. type TM 8334

(d) Modulation meter e.g. M.I. type TF 2300A

(e) Power meter M.I. Sanders 6598 with thermistor lead or R.F. millivoltmeter M.I. type TF 2603 with T connector and 50 Ω load

(f) Voltmeter e.g. M.I. Sensitive valve voltmeter TF 2600

5.3.2 Setting up the power supply voltages

Test equipment : item a.

Connect the multimeter set to its 25 V d.c. range between pin 15 on the 18 V power supply board and chassis, with its positive terminal connected to chassis. Adjust 2R12 to obtain a reading of 18 V on the multimeter.

Connect the multimeter set to its 100 V d.c. range between pin 11 on the 75 V power supply board and chassis, with its positive terminal connected to chassis. Adjust 1R11 to obtain a reading of 75 V on the multimeter.

Connect the multimeter set to its 10 V d.c. range between the 6.3 V heater line and chassis, preferably at the junction of 7C18/C20 and chassis, with its positive terminal connected to chassis. Ensure that a reading of about 6.3 V is obtained on the multimeter.

5.3.3 Setting up the modulation oscillator frequency

Test equipment : item b.

Connect the MODULATION OSCILLATOR OUTPUT on the back panel of the TF 2011 to the input of the counter. Switch the MODULATION SELECTOR to INTERNAL and the MODULATION ON/OFF switch to ON. Measure the modulation oscillator frequency at scale positions of 300 Hz, 1 kHz and 3 kHz. If the frequencies are not within 10%, reset the scale at 300 Hz by slackening the grub screws holding the knob, moving the knob and retightening the screws. Adjust C8 and C9 (each by the same amount) for the best accuracy at 1 kHz and 3 kHz.

5.3.4 Deviation accuracy

Test equipment : item d.

Connect the R. F. OUTPUT of the TF 2011 to the r. f. input of the modulation meter. Set the OUTPUT LEVEL control to +100 dBμV, Δ F CONTROL to zero and the FINE TUNE control central. At a modulating frequency of 1 kHz and a carrier frequency of 180 MHz, switch TF 2011 to INTERNAL MODULATION and set the F. M. RANGE switch to 30 kHz and the DEVIATION control to 3 (full-scale).

Adjust the MODULATION LEVEL control until the deviation indicated by the external modulation meter is 30 kHz. Adjust 5R23 until the modulation level meter is at its index mark.

Repeat with the F. M. RANGE switch at 3 kHz and then at 10 kHz, adjusting 5R22 and 5R21 respectively.

5.3.5 Deviation and Δf tracking

Test equipment : items d, f.

Any adjustment to the tracking network will affect f. m. and Δ f equally, but it is usually more convenient to do the setting up with respect to the f. m. performance.

Connect the deviation meter and set controls as in Sect. 5.3.4. Connect the voltmeter to the MODULATION DRIVE OUTPUT socket and set the deviation control so that the voltmeter indicates 1.5 V peak (1.06 V r.m.s.). Measure the deviation and, if necessary, adjust 7C22 so that the deviation is exactly 30 kHz. If 7C22 is adjusted, be sure to check sections 5.3.4 and 5.3.7.

Tune TF 2011 to 130 MHz and measure the deviation. If it is not 30 kHz, select a new value for 8R16.

Tune TF 2011 over its range, starting at the high frequency end, and measure the deviation at 14 points (3.3 MHz intervals). If at any point the deviation error exceeds 6% identify the lead from the corresponding tapping point on the tracking potentiometer and move it one step on the tracking network. Move the lead to a higher tag number if the deviation is too high or to a lower tag number if the deviation is too low. If such an adjustment is made the accuracy at all points should be rechecked.

5.3.6 Carrier frequency accuracy

Test equipment : items b, c.

Connect the counter/converter unit to the COUNTER OUTPUT of the TF 2011. Set the TF 2011 to C. W. and its MAIN TUNING dial to 130 MHz. Repeat this test at 10 MHz intervals throughout the frequency band.

If the scale calibration is in error the position of the tuning dial drum can be altered as follows :

(1) Remove the bottom cover by slackening the four M4 screws situated two on each side of the instrument.

(2) Loosen the screw in the perspex connector at the end of the tuning drive shaft.

(3) Re-position the ceramic rod and carefully retighten the screw.

5.3.7 Δ F accuracy

Test equipment : items b, c.

Connect the COUNTER OUTPUT of the TF 2011 to the r. f. input of the counter/converter. Set the OUTPUT LEVEL control to +100 dBμV, DEVIATION control to zero and the FINE TUNE control central. Set up a suitable carrier frequency on the TF 2011 and record the reading on the counter. Turn the Δ F RANGE switch to 10 kHz and the Δ F CONTROL to +10. Adjust 4R4 so that the counter shows the frequency to have increased by 10 kHz.

Repeat the test with the Δ F RANGE switch at 30 kHz and 100 kHz, in turn, adjusting 4R6 and 4R8 for frequency shifts of 30 kHz and 100 kHz respectively.

Turn the Δ F CONTROL to -10 and check whether the negative shift of frequency equals the positive one. If it does not, adjust 4R13 to equalize the shifts. Having adjusted 4R13, recheck the adjustment of 4R8.

5.3.8 Carrier level accuracy

Test equipment : item e.

Firstly check the setting of the SET CARRIER meter zero. Switch the instrument on from cold

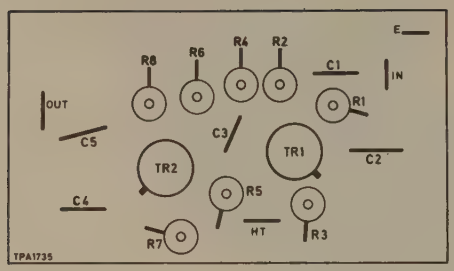


Fig. 5.1 Counter amplifier board layout

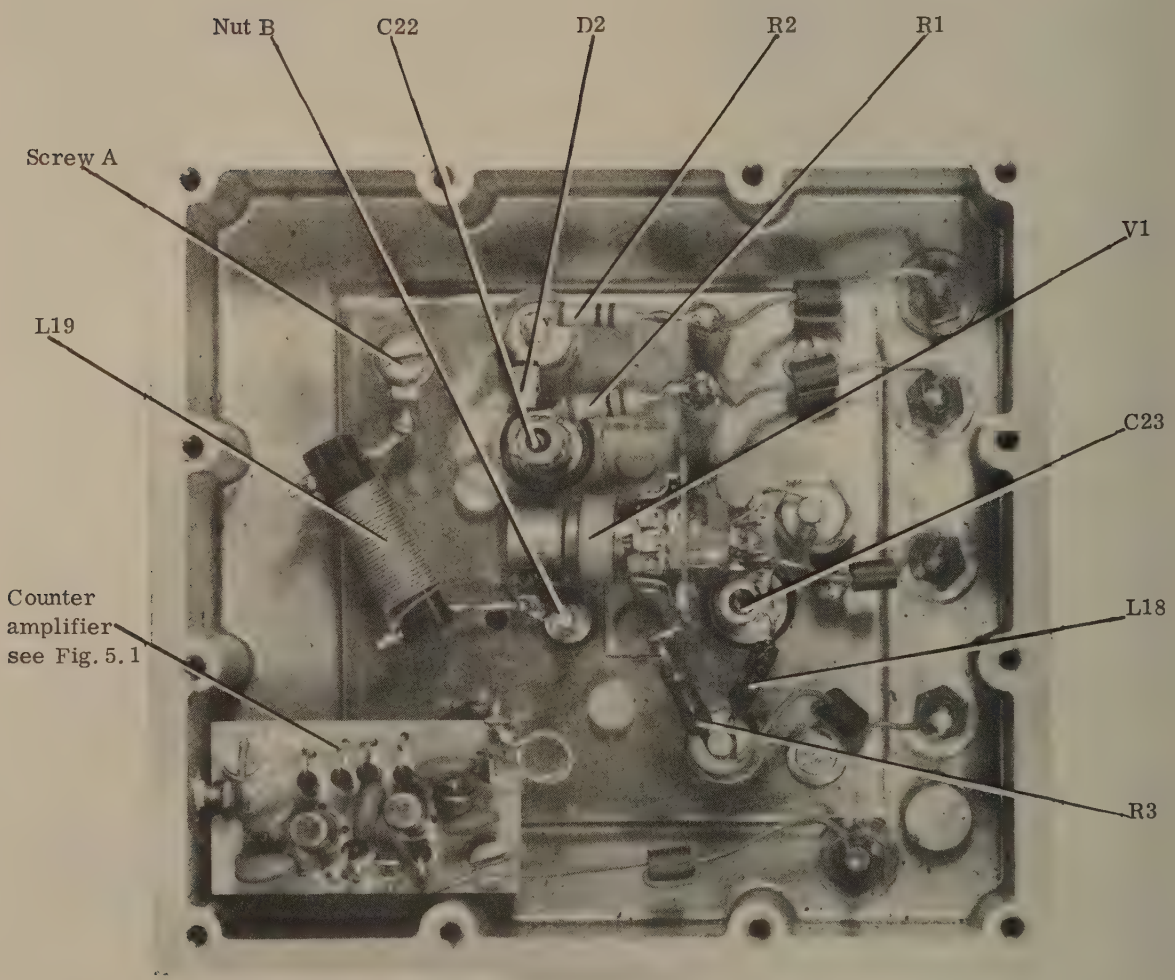


Fig. 5.2 Oscillator component layout

and adjust 5R24 so that the meter indicates at the white spot before the valve warms up. If necessary, stop the oscillator by disconnecting the lead to pin 4 on the 12 way plug on the oscillator casting when making the adjustment.

Connect to the R. F. OUTPUT socket either the power meter or the T connector with 50 Ω load and voltmeter.

Turn the SET CARRIER control fully clockwise and tune the signal generator over the band to find the point of lowest output. With the generator tuned to this point adjust the OUTPUT LEVEL control so that the output indicated by the power meter or voltmeter is about 1 dB above maximum rated output (110 mV or 250 μW).

Adjust the SET CARRIER control so that the output indicated by the power meter or voltmeter is the rated output (100 mV or 200 μW).

Adjust 5R25 so that the SET CARRIER LEVEL meter reads at its datum mark.

Reset the attenuator dial so that it indicates an output level of +106 dBμV e.m.f. Do this by slackening the two grub screws in the bellows coupling which connects the attenuator dial to the drive shaft, moving the attenuator dial by the required amount and re-tightening the grub screws.

5.3.9 Attenuator reaction

A compensatory circuit minimizes attenuator reaction at high outputs; to set it up:

(1) check that the microswitch, S7, operates at an attenuator scale setting of about 92 dBμV. If necessary slide the plastic cam along the attenuator shaft.

(2) check that the potentiometer R8 is at zero ohms at the microswitch operating point.

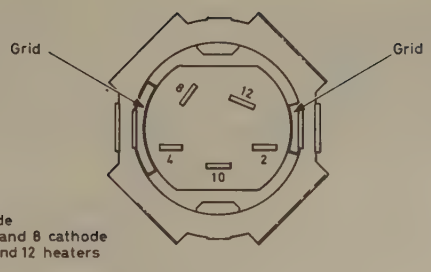


Fig. 5.3 Valve base connections of V1

If necessary reset it by slackening the coupling, turning the wiper shaft and refixing the coupling.

(3) adjust the preset control R7 to give the best correction of attenuator reaction as measured by the method in section 4.7.3.

5.4 REPLACEMENT OF OSCILLATOR VALVE

(1) Release the nut marked B and the screw marked A on Fig. 5.2.

(2) Unsolder the solder tag secured by screw A on Fig. 5.2 from the anode cap of V1.

(3) Slide the anode cap which should still be soldered to inductor L19 from V1 and extract V1 from its valve base.

(4) Re-locate the new valve and replace the anode cap and L19.

(5) Replace the solder tag secured by screw A and tighten the screw, finger tight.

(6) Replace the solder tag secured by the nut B and tighten the nut finger tight.

(7) Resolder the solder tag secured by screw A to the anode cap of V1.

(8) Tighten screw A and nut B.

Chapter 6

Replaceable parts

Introduction

Each of the printed boards and other sub-assemblies in this instrument has been allocated a unit identification number in the sequence (1) to (9). The complete circuit reference for a component carries its unit number as a prefix, e.g. 3R7. Components that do not form part of any sub-assembly carry the prefix 0, e.g. 0R5, except those classes of component about which no confusion is possible.

For convenience, in the text and on the circuit diagrams, the circuit reference is abbreviated by dropping the prefix, except where there is risk of ambiguity. When ordering spare parts or in any other correspondence, be sure to quote the complete circuit reference.

This section lists the components of each unit in alpha-numerical order of the complete circuit reference. The following abbreviations are used:

C : capacitor
Carb : carbon
Cer : ceramic
D : semiconductor diode
Elec : electrolytic
FS : fuse
L : inductor
M : meter
Met : metal
Ox : oxide
PL : plug
R : resistor
S : switch
SKT : socket
T : transformer
TR : transistor
Var : variable
WW : wirewound
Ø : feedthrough
† : value selected during test, nominal value shown
W : resistor rating at 70 °C

Ordering

When ordering replacement or spare parts, address the order to our Service Division (for address see rear cover) or nearest representative. Please specify the following information for each part required.

1. Type and serial number of instrument.
2. Complete circuit reference.
3. Description.
4. M.I. code number.

If a part is not listed, state its function, location and description when ordering.

One or more of the parts fitted to the instrument may differ from those listed in this chapter for any of the following reasons:

(a) Components indicated by † have their value selected during test to achieve particular performance limits.

(b) Owing to supply difficulties components may be substituted by others of different type or value provided that the overall performance of the instrument is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

Whenever there is such a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the instrument.

Unit [0] —Front panel assembly

When ordering, prefix circuit reference with 0.

Circuit reference	Description	M.I. code
C1	Elec 500μF +50-20% 200V	26427-109
C2	Elec 500μF +50-20% 200V	26427-109
C3	Elec 1000μF +50-20% 100V	26427-121
C4	Elec 1000μF +50-20% 100V	26427-121
FS1	230V	23411-054
	115V	23411-055
M1	200μA Modulation level meter	44558-414
M2	200μA Carrier level meter	44558-414
PL1	Mains plug	23423-151
PL2	Part of assembly	
PL3	Conhex, 50Ω	23444-361
PL4	TNC, 50Ω	23444-891 / 23443-369
R1	Met ox 68Ω 2% ½W	24573-045
R2	WW 6.8Ω 5% 3W	25125-014
R3	Var. WW 4.7kΩ 20% 2W	25645-369
R4	Var. WW 1.6kΩ 3% 3/4W	25812-694
R5	Var. WW 10kΩ 3% 3/4W	25812-696
R6	Var. Carb 4.7kΩ 20% 2W	25645-368
R7	Var. Carb 22kΩ 20% ¼W	25611-180
R8	Var. Carb 4.7kΩ Log 20% 1W	25657-501
R9	Var. Carb 4.7kΩ 20% 2W	25645-369
R10	Met ox 10kΩ 2% ½W	24573-097
R11	Met ox 1.2kΩ 2% ½W	24573-075
R12	Special 100kΩ 20%	44368-006
R13	Met ox 4.7kΩ 2% ½W	24573-089
SK1	BNC receptacle	23443-443
SK2	BNC receptacle	23443-443
SK3	BNC receptacle	23443-443
SK4	BNC receptacle	23443-443
SK5	Conhex bulkhead receptacle	23444-382
SK6	Jack socket and cable assy.	43126-048
SK7	Bulkhead jack	23443-767
SK8	12 pole	23435-051
SK9	TNC, 50Ω	23444-813
SW1	D.P.D.T.	23462-258
SW2	D.P.D.T.	23467-119
SW3	S.P.D.T.	23462-252
SW4	D.P.D.T.	23462-258
SW5	D.P.D.T.	23462-257
SW6	D.P.D.T.	23462-257
SW7	U.H.F. microswitch	23483-131
SW8	D.P.D.T.	23462-257
T1	Mains transformer	43453-018
TR1	NKT403	28423-924
V2	Neon indicator	23733-115
X1	Ferrite bead	23635-833
X2	Ferrite bead	23635-833
X3	Ferrite bead	23635-833
X4	Ferrite bead	23635-833

For symbols and abbreviations see introduction to this chapter

Unit [1] —75 V Power unit

When ordering, prefix circuit reference with 1.

Circuit reference	Description	M.I. code
C1	Elec 25μF +50-20% 150V	26417-484
C2	Paper 0.001μF 10% 500V	26174-125
C3	Elec 1μF +100-20% 50V	26414-106
C4	Elec 25μF +50-20% 150V	26417-484
C5	Elec 25μF +100-20% 70V	26417-145
D1	1N4004	28357-028
D2	1N4004	28357-028
D3	1N4004	28357-028
D4	1N4004	28357-028
D5	Zener 18V	28372-583
R1	Met ox 100Ω 2% ½W	24573-049
R2	Met ox 15kΩ 2% ½W	24573-101
R3	Met ox 12Ω 2% ½W	24573-027
R4	Met ox 1kΩ 2% ½W	24573-073
R5	Met ox 10kΩ 2% ½W	24573-097
R6 †	Met ox 220kΩ 2% ½W	24573-129
R7	Met ox 8.2kΩ 2% ½W	24573-095
R8	Met ox 100Ω 2% ½W	24573-049
R9	Met ox 100Ω 2% ½W	24573-049
R10	Met ox 12kΩ 2% ½W	24573-099
R11	Var. WW 1kΩ 10% 1W	25811-019
R12	Met ox 3.9kΩ 2% ½W	24573-087
TR1	MM4001	28438-436
TR2	MM4001	28438-436
TR3	MM4001	28438-436
TR4	MM4001	28438-436

Unit [2] —18 V Power unit

When ordering, prefix circuit reference with 2.

Circuit reference	Description	M.I. code
C1	Elec 100μF +100-20% 50V	26417-160
C2	Paper 0.001μF 10% 500V	26174-125
C3	Elec 1μF +100-20% 50V	26414-106
C4	Elec 50μF +100-20% 50V	26417-189
C5	Elec 100μF +100-20% 25V	26417-158
D1	1N4004	28357-028
D2	1N4004	28357-028
D3	1N4004	28357-028
D4	1N4004	28357-028
D5	Zener 8.2V	28371-203
R1	Met ox 100Ω 2% ½W	24573-049
R2	Met ox 15kΩ 2% ½W	24573-101
R3	Met ox 3.3Ω 5% ½W	24552-008
R4	Met ox 1kΩ 2% ½W	24573-073
R5	Met ox 3.9kΩ 2% ½W	24573-087
R6 †	Met ox 100kΩ 2% ½W	24573-121
R7	Met ox 1.8kΩ 2% ½W	24573-079
R8	WW 82Ω 5% 3W	25125-046
R9	Met ox 100Ω 2% ½W	24573-049
R10	Met ox 100Ω 2% ½W	24573-049
R11	Met ox 2.4kΩ 2% ½W	24573-082
R12	Var. WW 470Ω 10% 1W	25811-017
R13	Met ox 2.2kΩ 2% ½W	24573-081
TR1	2N2904	28434-878
TR2	2N2904	28434-878
TR3	BCY71	28435-235

For symbols and abbreviations see introduction to this chapter

Unit [3] —Modulation oscillator

When ordering, prefix circuit reference with 3.

Circuit reference	Description	M.I. code
C1	Elec 50μF +100-20% 25V	26423-317
C2	Elec 50μF +100-20% 25V	26423-317
C3	Paper 0.003μF 10% 350V	26174-133
C4	Cer 10pF ±0.25pF 750V	26324-709
C5	Elec 50μF +100-20% 25V	26423-317
C6	Var. 280pF	26878-501
C7	Var. 280pF	
C8	Var. 9pF	
C9	Var. 9pF	
R1	Met ox 47Ω 5% ½W	24552-037
R2	Met ox 10kΩ 5% ½W	24552-110
R3	Var. Carb 100kΩ 20% 0.21W	25541-346
R4	Met ox 47kΩ 5% ½W	24552-126
R5	Carb 2MΩ 1% ½W	24157-200
R6	Met ox 22kΩ 5% ½W	24552-118
R7	Met ox 220Ω 5% ½W	24552-058
R8	Met ox 5.6kΩ 5% ½W	24552-103
R9	Met ox 10kΩ 5% ½W	24552-110
R10	Met ox 220Ω 5% ½W	24552-058
R11	Met ox 33Ω 5% ½W	24552-033
R12	Thermistor 10kΩ 20%	25683-377
R13	Met ox 680Ω 5% ½W	24552-076
R14	Carb 2MΩ 1% ½W	24157-200
R15	Met ox 100kΩ 5% ½W	24552-135
R16	Met ox 560Ω 5% ½W	24552-072
TR1	2N3819	28459-003
TR2	BCY71	28435-235
TR3	BC108	28452-787

Unit [4] —Incremental frequency board

When ordering, prefix circuit reference with 4.

Circuit reference	Description	M.I. code
C1	Elec 10μF +100-20% 70V	26417-128
C2	Elec 25μF +50-20% 150V	26417-484
D1	1S44	28357-548
R1	Met 18kΩ 1% ¼W	24637-515
R2	Met 18kΩ 1% ¼W	24637-515
R3	Met ox 750kΩ 2% ½W	24573-142
R4	Var. carb 470kΩ 20% ¼W	25611-088
R5	Met ox 300kΩ 2% ½W	24573-132
R6	Var. carb 47kΩ 20% ¼W	25611-082
R7	Met ox 15kΩ 2% ½W	24573-101
R8	Var. carb 10kΩ 20% ¼W	25611-078
R9	Met 47kΩ 0.5% ¼W	24635-554
R10	Met 47kΩ 0.5% ¼W	24635-554
R11	Met ox 100kΩ 2% ½W	24573-121
R12	Met ox 10kΩ 2% ½W	24573-097
R13	Var. carb 100kΩ 20% ¼W	25611-084
R14	Met 51kΩ 0.5% ¼W	24635-603
R15	Met 47kΩ 0.5% ¼W	24635-554

Unit [5] —Deviation drive and monitor board

When ordering, prefix circuit reference with 5.

Circuit reference	Description	M.I. code
C1	Elec 50μF +100-20% 25V	26423-317
C2	Elec 50μF +100-20% 25V	26423-317
C3	Paper 0.5μF 10% 150V	26174-179
C4	Elec 10μF +100-20% 70V	26417-128
C5	Paper 0.5μF 10% 150V	26174-179

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
D1	1S44	28357-548
D2	1S44	28357-548
D3	1S44	28357-548
D4	CG92H	28321-161
R1	Met ox 10kΩ 2% ½W	24573-097
R2	Met ox 680Ω 2% ½W	24573-069
R3	Met ox 27kΩ 2% ½W	24573-107
R4	Met ox 10kΩ 2% ½W	24573-097
R5	Met ox 3.3kΩ 2% ½W	24573-085
R6	Met ox 470Ω 2% ½W	24573-065
R7	Met ox 390Ω 2% ½W	24573-063
R8	Met ox 2.2kΩ 2% ½W	24573-081
R9	Met ox 7.5kΩ 2% ½W	24573-094
R10	Met ox 22kΩ 2% ½W	24573-105
R11	Met ox 4.7kΩ 2% ½W	24573-089
R12	Met ox 220kΩ 2% ½W	24573-129
R13	Met ox 3.3kΩ 2% ½W	24573-085
R14	Met ox 10kΩ 2% ½W	24573-097
R15	Met ox 680Ω 2% ½W	24573-069
R16	Met ox 1kΩ 2% ½W	24573-073
R17	Met ox 47kΩ 2% ½W	24573-113
R18	Met ox 47kΩ 2% ½W	24573-113
R19	Met ox 47Ω 2% ½W	24573-041
R20	Met ox 33kΩ 2% ½W	24573-109
R21	Var. WW 470Ω 10% 1W	25811-017
R22	Var. WW 1.5kΩ 10% 1W	25811-020
R23	Var. carb 10kΩ 20% ¼W	25611-078
R24	Var. WW 100Ω 10% 1W	25811-013
R25	Var. WW 4.7kΩ 10% 1W	25811-023
R26	Thermistor 1.5kΩ 20 °C	25683-644
TR1	BCY71	28435-235
TR2	BC108	28452-787
TR3	BC108	28452-787

Unit [6] —Counter amplifier

When ordering, prefix circuit reference with 6.

Circuit reference	Description	M.I. code
C1	Cer 0.001μF +80-20% 500V	26383-242
C2	Cer 0.001μF +80-20% 500V	26383-242
C3	Cer 0.001μF +80-20% 500V	26383-242
C4	Cer 0.001μF +80-20% 500V	26383-242
C5	Cer 0.001μF +80-20% 500V	26383-242
R1	Met ox 2.7kΩ 2% ¼W	24511-592
R2	Met ox 10kΩ 2% ¼W	24511-610
R3	Met ox 180Ω 2% ¼W	24511-556
R4	Met ox 390Ω 2% ¼W	24511-565
R5	Met ox 2.7kΩ 2% ¼W	24511-592
R6	Met ox 10kΩ 2% ¼W	24511-610
R7	Met ox 150Ω 2% ¼W	24511-554
R8	Met ox 390Ω 2% ¼W	24511-565
TR1	BFY90	28452-157
TR2	BFY90	28452-157

Unit [7] —R.F. oscillator assembly

When ordering, prefix circuit reference with 7.

Circuit reference	Description	M.I. code
C1	Cer Ø 0.0047μF +80-20% 500V	26373-665
C2	Cer Ø 0.0047μF +80-20% 500V	26373-665

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C3	Cer Ø 56pF 20% 500V	26373-855
C4	Cer Ø 0.001μF +80-20% 500V	26373-714
C5	Cer Ø 0.0047μF +80-20% 500V	26373-665
C6	Cer Ø 0.0047μF +80-20% 500V	26373-665
C7	Cer Ø 0.0047μF +80-20% 500V	26373-665
C8	Cer Ø 0.001μF +80-20% 500V	26373-714
C9	Cer Ø 56pF 20% 500V	26373-855
C10	Cer Ø 0.001μF +80-20% 500V	26373-714
C11	Cer Ø 0.0047μF +80-20% 500V	26373-665
C12	Cer Ø 0.0047μF +80-20% 500V	26373-665
C13	Cer Ø 0.0047μF +80-20% 500V	26373-665
C15	Cer Ø 56pF 20% 500V	26373-855
C16	Cer Ø 0.001μF +80-20% 500V	26373-714
C17	Cer Ø 0.0047μF +80-20% 500V	26373-665
C18	Cer Ø 0.0047μF +80-20% 500V	26373-665
C19	Cer 47pF 10% 500V	26373-815
C20	Cer 47pF 10% 500V	26373-815
C21	Cer 0.001μF 20% 500V	26373-785
C22	Var. 3-20pF 350V	26845-147
C23	Var. 0.5-5pF 350V	26845-141
C24	Cer 47pF 10% 500V	26373-815
C25	15pF	part of cavity assembly
C26	10pF	part of cavity assembly
C27	Var. 1-4 pF	part of cavity assembly
C28	0.001μF	part of cavity assembly
C29	Cer 10pF ±0.25pF 750V	26324-709
D1	CG92H	28321-161
D2	PC115	28381-486
L1	10μH	23642-555
L2	4.7μH	23642-553
L3	4.7μH	23642-553
L4	4.7μH	23642-553
L5	10μH	23642-555
L6	10μH	23642-555
L7	10μH	23642-555
L8	4.7μH	23642-553
L9	4.7μH	23642-553
L10	4.7μH	23642-553
L11	10μH	23642-555
L12	10μH	23642-555
L18	10μH	23642-555
L19	1.75μH	44137-203
L20	Part of assembly	
L21	Part of assembly	
R1	Met ox 100kΩ 2% ½W	24573-121
R2	Met ox 100kΩ 2% ½W	24573-121
R3	Met ox 1kΩ 2% ½W	24573-073
R4	Met ox 50Ω 1% 1/8W	24616-321
R5	Met ox 50Ω 1% 1/8W	24616-321
V1	RCA-8058	28127-477

Unit [8] —Tracking network

When ordering, prefix circuit reference with 8.

Circuit reference	Description	M.I. code
C1	Plas 330pF 2% 125V	26516-369
R1	Met ox 2.7kΩ 2% ½W	24573-083

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R2	Met ox 2.7kΩ 2% ½W	24573-083
R3	Met ox 3.3kΩ 2% ½W	24573-085
R4	Met ox 3.3kΩ 2% ½W	24573-085
R5	Met ox 3.3kΩ 2% ½W	24573-085
R6	Met ox 3.3kΩ 2% ½W	24573-085
R7	Met ox 3.3kΩ 2% ½W	24573-085
R8	Met ox 2.7kΩ 2% ½W	24573-083
R9	Met ox 2.7kΩ 2% ½W	24573-083
R10	Met ox 2.2kΩ 2% ½W	24573-081
R11	Met ox 2.7kΩ 2% ½W	24573-083
R12	Met ox 3.3kΩ 2% ½W	24573-085
R13	Met ox 4.7kΩ 2% ½W	24573-089
R14	Met ox 4.7kΩ 2% ½W	24573-089
R15	Met ox 5.6kΩ 2% ½W	24573-091
R16†	Met ox 6.8kΩ 2% ½W	24573-093
R17	Met ox 6.8kΩ 2% ½W	24573-093

Unit [9] —Output filter

When ordering, prefix circuit reference with 9.

Circuit reference	Description	M.I. code
C1, C2	Part of assembly	
L1		44278-214
R1	Met film 436Ω 1% ¼W	24636-711
R2	Met film 11.6Ω 1% ¼W	24636-113
R3	Met film 436Ω 1% ¼W	24636-711

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

1. COMPONENT VALUES

Resistors: No suffix = ohms, k = kilohms, M = megohms.
Capacitors: No suffix = microfarads, p = picofarads.

2. VOLTAGES

Shown in italics adjacent to the point to which the measurement refers. See section 4.5 for conditions.

3. SYMBOLS

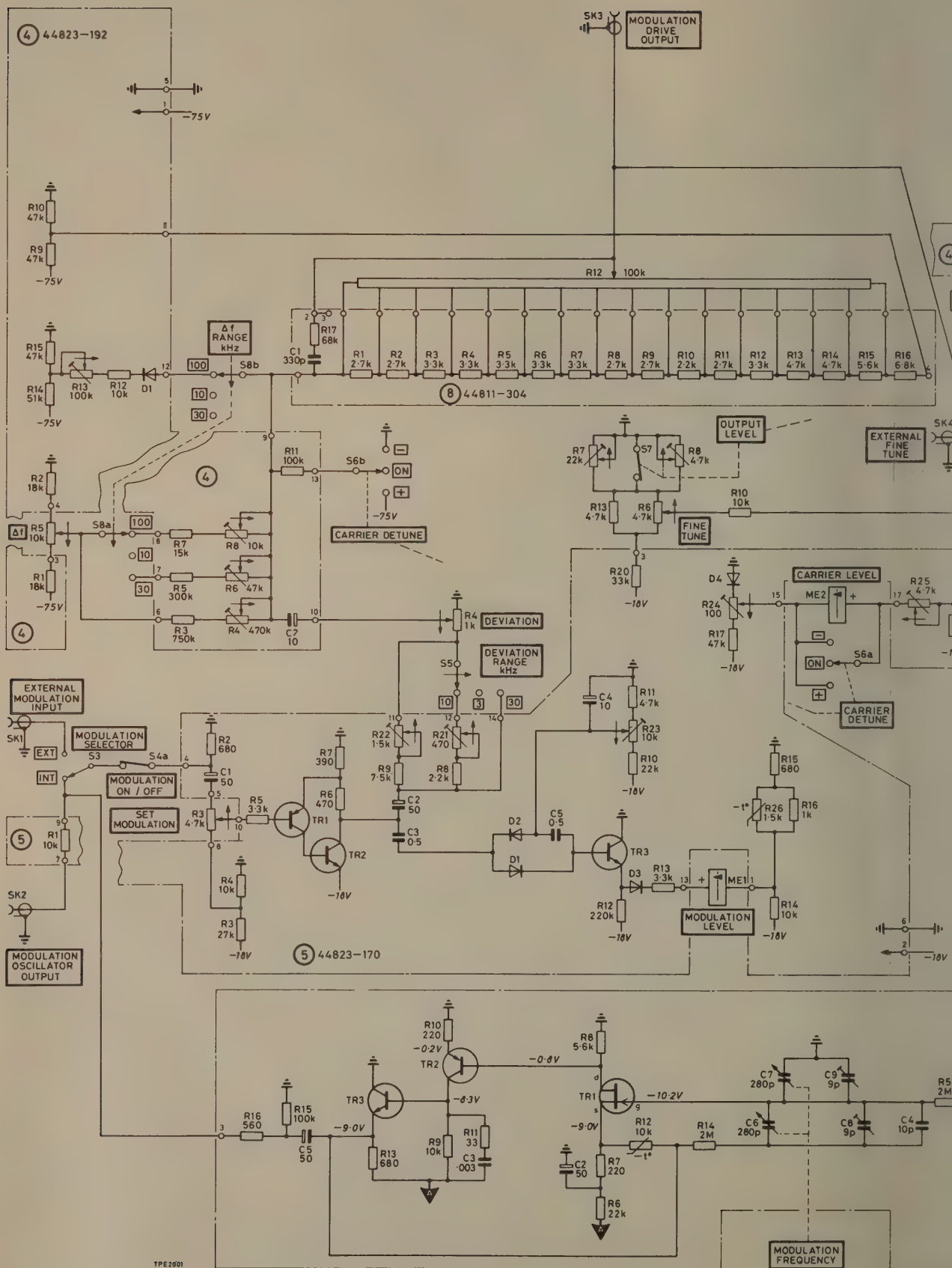
+► arrow indicates clockwise rotation of knob.

RANGE etc., external front or rear panel marking.

④ unit identification number.

4. CIRCUIT REFERENCES

These are, in general, given in abbreviated form.
See also introduction to Chapter 6.


4 44823-192
SK3
MODULATION DRIVE OUTPUT
-75V
R10 47k
R9 47k
R12 100k
Δf RANGE kHz
R15 47k
R14 51k
R13 100k
R12 10k
D1
S8b
C1 330p
R17 68k
R1 2·7k
R2 2·7k
R3 3·3k
R4 3·3k
R5 3·3k
R6 3·3k
R7 3·3k
R8 2·7k
R9 2·7k
R10 2·2k
R11 2·7k
R12 3·3k
R13 4·7k
R14 4·7k
R15 5·6k
R16 6·8k
8 44811-304
OUTPUT LEVEL
EXTERNAL FINE TUNE
R7 22k
S7
R8 4·7k
R13 4·7k
R6 4·7k
FINE TUNE
R10 10k
R11 100k
S6b
ON
CARRIER DETUNE
R2 18k
R5 10k
S8a
R7 15k
R8 10k
R5 300k
R6 47k
R1 18k
R3 750k
R4 470k
C2 10
R20 33k
D4
CARRIER LEVEL
ME2
R24 100
R17 47k
R25 4·7k
S6a
R4 1k
DEVIATION
S5
DEVIATION RANGE kHz
EXTERNAL MODULATION INPUT
SK1
EXT
INT
S3
S4a
MODULATION SELECTOR
MODULATION ON / OFF
SET MODULATION
R2 680
C1 50
R3 4·7k
R5 3·3k
R22 1·5k
R21 470
R9 7·5k
R8 2·2k
C4 10
R11 4·7k
R23 10k
R10 22k
R7 390
R6 470
TR1
TR2
C2 50
C3 0·5
D2
C5 0·5
D1
TR3
D3
R13 3·3k
ME1
MODULATION LEVEL
R15 680
R26 1·5k
R16 1k
R14 10k
R12 220k
R1 10k
R4 10k
R3 27k
SK2
MODULATION OSCILLATOR OUTPUT
5 44823-170
R10 220
TR2
R8 5·6k
TR3
TR1
R15 100k
R16 560
C5 50
R13 680
R9 10k
R11 33
C3 ·003
R12 10k
R14 2M
C7 280p
C9 9p
C6 280p
C8 9p
C4 10p
C2 50
R7 220
R6 22k
TPE2001
MODULATION FREQUENCY

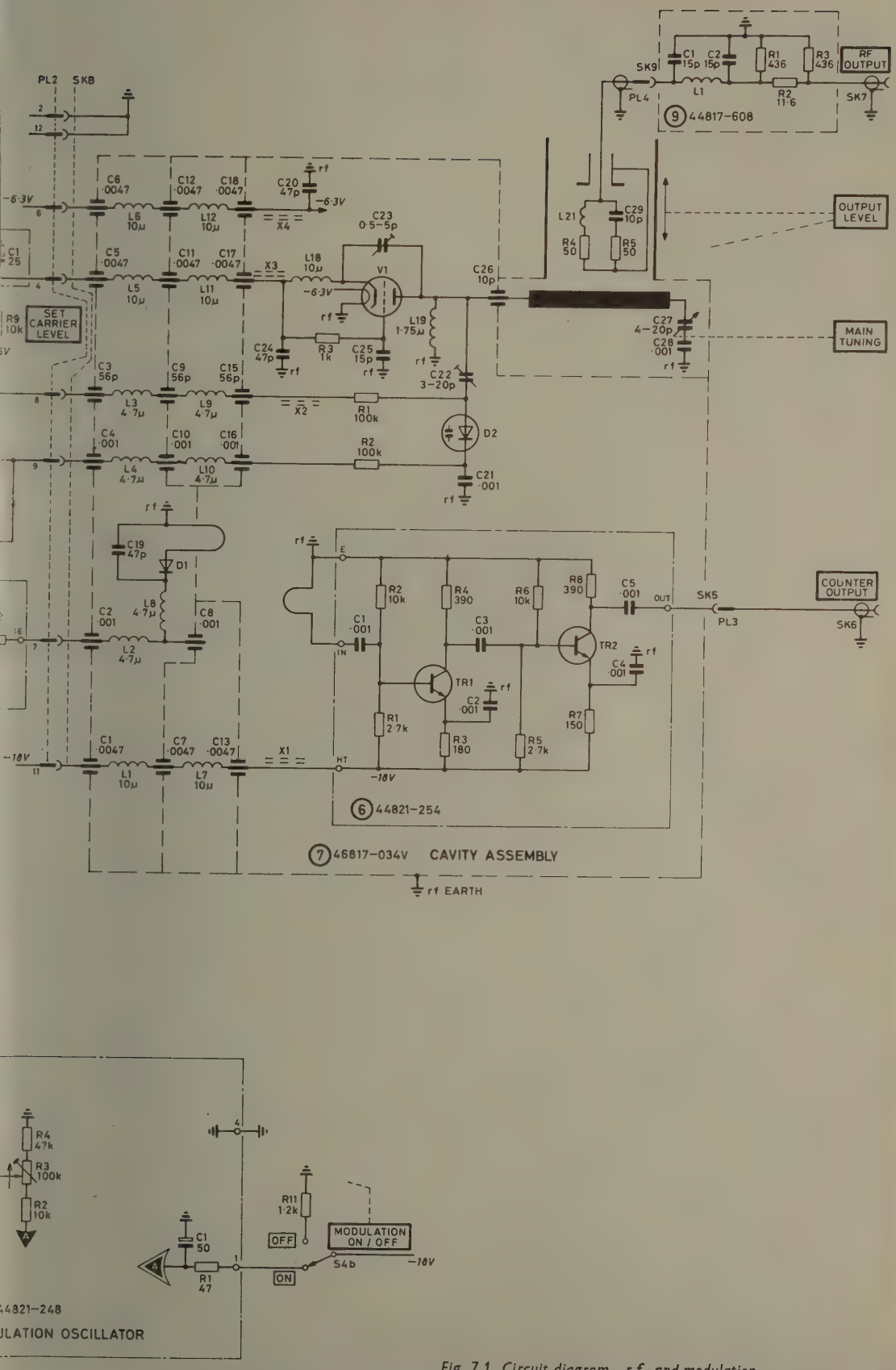
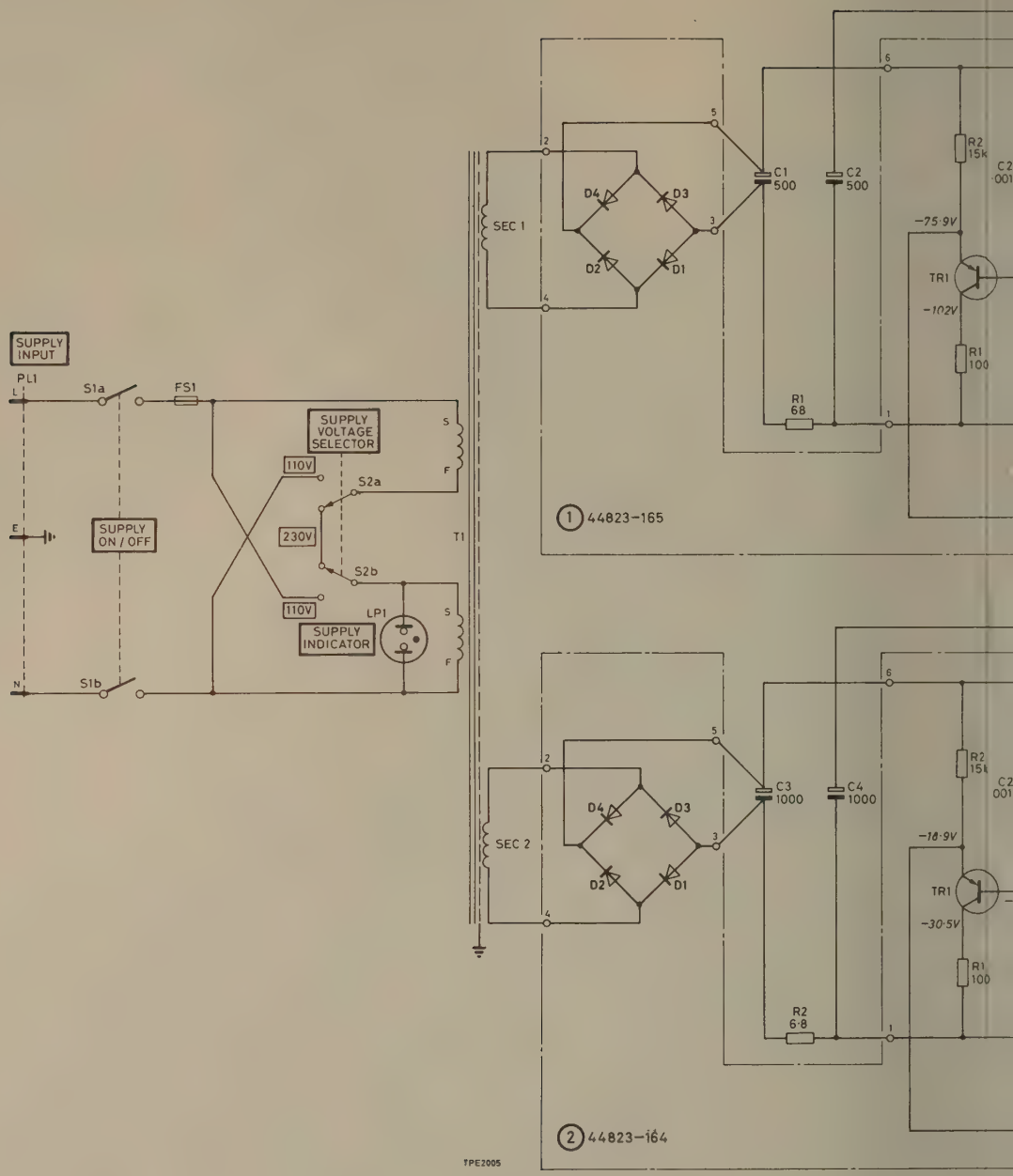


Fig. 7.1 Circuit diagram—r.f. and modulation


SUPPLY INPUT
PL1
L
N
E
S1a
S1b
FS1
SUPPLY ON / OFF
SUPPLY VOLTAGE SELECTOR
110V
230V
110V
S2a
S2b
T1
S
F
S
F
LP1
SUPPLY INDICATOR
SEC 1
SEC 2
D1
D2
D3
D4
C1 500
C2 500
C3 1000
C4 1000
R1 68
R2 6·8
R2 15k
R1 100
TR1
-75·9V
-102V
-18·9V
-30·5V
1
2
3
4
5
6
1 44823-165
2 44823-164
TPE2005

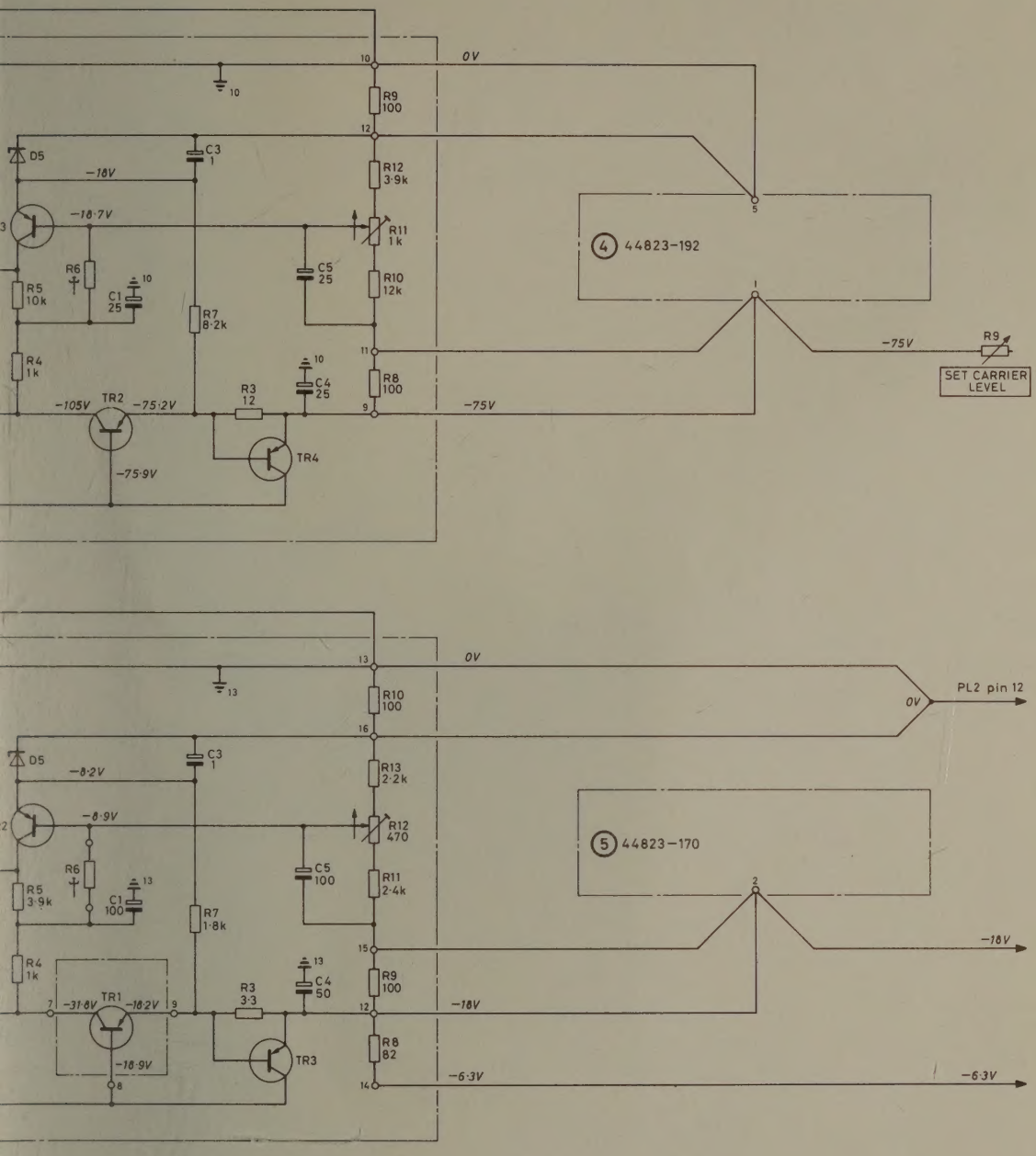


Fig. 7.2 Circuit diagram—power supplies

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